Report of Proceedings

CONFERENCE ON MILK CONCENTRATES

October 17 and 18, 1955

Conference was held at the Eastern Utilization Research Branch with representatives from industry, the State Agricultural Experiment Stations, universities, milk processors, and the U. S. Department of Agriculture and other Federal agencies participating.

This report summarizes the discussions of the various speakers during the conference. If further details regarding any particular subject are desired, they may be obtained by communicating with the person concerned (see appended list of names and addresses).

Eastern Utilization Research Branch
Agricultural Research Service
U. S. Department of Agriculture
Philadelphia 18, Pennsylvania

PROGRAM

Monday, October 17

9:30 a.m.	Registration	
9:45 a.m.	Introductory Remarks	P. A. Wells, Chief of Branch

GENERAL

10:00 a.m.

1. Importance of Milk Concentrates in the Marketing and Utilization of Dairy Products — Don S. Anderson, Commodity Stabilization Service, U. S. D. A., Washington, D. C.

10:30 a.m. Discussion

10:45 a.m.

2. What Forms of Concentrated Milk are Needed for Human Consumption — Philip B. Dwoskin, Agricultural Marketing Service, U. S. D. A., Washington, D. C.

11:30 a.m. Discussion

11:45 a.m.

3. Types of Nonfat Dry Milk Required by the Food Manufacturers — R. J. Remaley, American Dry Milk Institute, Chicago 1, Illinois, Presented by Robert Osborn

12:30 p.m. LUNCH

FLUID CONCENTRATES

2:00 p.m.

4. The Methods and Problems Found in the Production of Concentrated Milk — Victor Nelson, Food Machinery and Chemical Corp., San Jose, California

2:30 p.m. Discussion

Monday, October 17 (Continued)

2:45 p.m.

5. Some Effects of Heat on the Constituents of Milk — Robert Jenness, University of Minnesota, St. Paul, Minnesota

3:15 p.m. Discussion

3:30 p.m. Tour of Laboratory

Tuesday, October 18

9:00 a.m.

6. High-Temperature Short-Time Sterilization of Whole Milk and of Concentrated Milk — Ernest O. Herreid, Illinois Agricultural Experiment Station, Urbana, Illinois

9:30 a.m. Discussion

9:45 a.m.

7. Development of Market Milk Concentrates in Iowa — C. A. Iverson, Iowa State College, Ames, Iowa

10:15 a.m. Discussion

10:30 a.m.

8. The Chemistry of Flavor Changes in Milk — Stuart Patton, Pennsylvania State University, University Park, Pennsylvania

11:00 a.m. Discussion

DRIED CONCENTRATES

11:15 a.m.

9. Methods and Problems in the Production of Spray-Dried Milk — S. T. Coulter, University of Minnesota, St. Paul, Minnesota

11:45 a.m. Discussion

12:00 Noon LUNCH

Tuesday, October 18 (Continued)

1:30 p.m.

10. Dispersibility of Dried Milks — H. A. Hollender, Quartermaster Food and Container Institute, Chicago, Illinois

2:00 p.m. Discussion

2:15 p.m.

11. Use of Electrolytic Tinplate in Packaging of Milk Concentrates — E. A. Tjarks, The Borden Company, New York, New York

2:45 p.m. Discussion

3:00 p.m. General Discussion

3:30 p.m. Adjournment

INTRODUCTORY REMARKS

by

P. A. Wells, Eastern Utilization Research Branch

Dr. Wells opened the conference by requesting each delegate to stand and introduce himself. He pointed out that the present conference represented the annual meeting of the State Agricultural Experiment Station Collaborators for the Eastern Region.

Some 10 years ago Dr. Auchter, the Agricultural Research Administrator for the Department at that time, established the mechanism for State Experiment Station collaboration with the Regional Research Laboratories. A collaborator is appointed from each State Experiment Station in the region, who attends an annual conference devoted to research on a specific subject, either an agricultural commodity or a general field like methodology. In the past, conferences have been devoted to such subjects as tobacco, potatoes, fruits, maple, waste disposal, methodology, and others. In addition to collaborators from Stations of the Eastern Region, the meetings are usually attended by interested members of State Experiment Stations outside the region, representatives of industry, universities, privately endowed research institutions, and representatives of other agencies of the Federal and State Governments. The present conference promises to be the largest of any held here so far.

A report of the conference will be prepared and it is expected to be ready in about 2 months. Each delegate will receive a copy, extra copies being supplied on request.

IMPORTANCE OF MILK CONCENTRATES IN THE MARKETING AND UTILIZATION OF DAIRY PRODUCTS

by

Don S. Anderson, Commodity Stabilization Service
Washington, D. C.

Milk as it comes from the cow contains about 87 percent water. If any or most of this water is removed I assume we have a milk concentrate of some kind. The processes commonly used may remove only water, or water and a small or a considerable part of the non-water part of the milk. During the past year and a half Commodity Credit Corporation has had about 127 million pounds of butter made into butter oil mostly for donation to welfare agencies made up of United States citizens for use by needy people in other lands. Since January 1952, over one billion pounds of nonfat dry milk solids has passed through Commodity Credit Corporation inventory on its way to school lunch programs in this country and to welfare agencies both in this and in other lands.

Recently we have had discussions with a United States company that is considering building plants in other lands to recombine these products with the local water supply in order to furnish fluid milk to the people of those lands.

During recent years the Commodity Credit Corporation has had a great deal of experience in taking water out of milk. The concentrated product has done almost entirely for welfare uses. The question before this conference that interests me most is that of whether or not milk concentrates offer any promise of so increasing the commercial utilization of dairy products that it will be possible for the Commodity Credit Corporation to get out of the dairy business without any further loss of income to dairy farmers. We must look for the answer to the question, "Why should we first go to the trouble of removing water from milk merely to create for the housewife the problem of getting the water back into the milk?" Or perhaps it is possible to avoid the housewife's problem by telling her or industry of ways that concentrated milk can be used without restoring water that has previously been taken away.

Milk, of course, is not the only food that contains a large proportion of water. Agriculture Handbook No. 8 carries three tables giving the composition of foods. Table No. 1 of this handbook gives the percentage of water in some 750 food items. The following from that table carry considerable amounts of water.

Raw strawberries, we are informed, carry 89.9 percent of water. I suppose a strawberry could be dried. It does not, however, occur to me that this would be the right thing to do.

Raw cabbage has 92.4 percent, raw broccoli has 89.9 percent, while raw carrots have 88.2 percent. A grapefruit carries 88.8 percent of water, an orange 87.2. Even such substantial foods as meat have a fair proportion of water. A raw beef carcass, medium fat, trimmed to retail, still has 63 percent of water. A thin packer's carcass of fresh pork is half water, and a medium fat boned veal cutlet in its raw state is almost 70 percent water. A raw whole egg is almost three-fourths water; brains, of all kinds, in their raw state are even wetter -- 78.9 percent water.

Item No. 88 of this list of 751 items attracted my attention -- "Beer (average, 4 percent alcohol) -- 90.2 percent water." Thus far I have heard of no work on beer concentrate.

I have recited these figures to emphasize some bewilderment I have always had about the concern over getting the water out of milk. There are, of course, a number of reasons for it. First among these might be the fact that so far we have been unable to get customers who would drink all the milk that has been produced. If this could be done, certain problems would be solved. First, all the food elements in milk would be used as food. Secondly, certain problems generally classed as "waste disposal" would also be solved. I understand this is one of the problems being worked on at this laboratory.

This particular problem happens to be in the forefront of my attention at the moment, for we are being threatened by a possible request to buy dried whey of animal feed grade under the price support program. Because cheese does not use all of the elements of milk and because some people do not like liquid whey in their streams, Commodity Credit Corporation may be asked to buy dried whey.

It is estimated that during 1954 the average civilian in this country consumed the equivalent of 699 pounds of milk in all dairy products. Of this 699 pounds, 349 pounds or 50.1 percent is estimated to have been consumed as fluid milk and cream. This is a total per day of .96 pound of fluid consumption and 1.9 pounds per day of milk equivalent in all forms.

If people could be convinced to consume one quart of milk per day, our total production of milk would be used; and we would not have to worry about milk concentrates, except for the fact that as dairying is now carried on there are seasonal variations in milk production. In addition to seasonal variations, there are regional differences in milk production and the areas of greatest milk production do not match the areas of greatest population.

Even though it were possible to convince people that they should drink 120 billion pounds of milk per year, we could still be faced with the need for concentrating a part of our milk supply. This could arise from the fact, first, that the same amount of milk is not produced each month of the year and, secondly, that the distribution of milk production does not correspond to the distribution of population. The first of these facts leads to the storing of dairy products from season to season; the second, to the necessity of transporting dairy products from place to place.

With respect to the second of these, there appears to be a race in technology between improvements in transportation and improvements in processing. The development of bulk tanks for holding milk on the farm and of bulk tank transport appears to be increasing greatly the distances over which whole milk is being transported.

This problem of transportation and the regional distribution of milk production calls for mention of one of the Department's regulatory activities in the field of milk marketing. Federal milk marketing orders regulate the pricing of milk sold in defined milk marketing areas. Generally these defined milk marketing areas have one or similar sanitary codes covering the sale of milk and certain defined milk products in the area. These codes do not cover all the dairy products sold in the area. The result is that dairy products sold in the area are produced under different sets of sanitary regulations.

A few years ago some companies attempted to introduce 3-to-1 concentrate in markets operating under Federal milk marketing orders. This raised the question of which set of sanitary regulations should be applied to milk used in the making of 3-to-1 concentrate. Health authorities, I believe without exception, ruled that since this product was not sterilized, the milk used in its production should be covered by the same regulations as applied to milk used for distribution as fresh fluid milk.

This ruling has been criticized by some who had hoped that 3-to-1 concentrate would supply them with a means to sell milk not meeting the sanitary code of the market in which they wish to sell. It is an issue that has divided the dairy industry into camps, frequently at war with each other.

There is the one made up of those who believe that if the inherent quality of fresh milk as it comes from healthy cows is fully preserved, the

domestic markets would easily absorb all milk currently being produced. There appears to be considerable evidence to support this view.

Of the general categories of dairy products used in the United States Department of Agriculture Statistics, three have improved their position substantially during the past 30 years. Frozen dairy products used 2.5 percent of all milk produced in 1924; by 1954, these products were using 6.2 percent of the total. Cheese increased its utilization of milk from 5.1 percent in 1924 to 10.9 percent in 1954. The consumption of fluid milk and cream required 41.5 percent in 1924 -- 30 years later 46.2 percent was required for this purpose.

Two general circumstances possibly were responsible for these increases. Under the persistent urging of bureaucrats, often greatly helped by the efforts of the milk distributors, the quality and safety of fluid milk has been improved and is reasonably uniform from city to city. Better and better merchandising probably contributed greatly to the increase.

Quality and merchandising appear to be the factors that will determine the importance of any particular dairy product in the future utilization of our total milk. When the two are combined in a joint effort, we see results such as those obtained in the sale of cottage cheese in California, where it appears that 8 percent of the nation's total population eat almost one-fifth of all the creamed cottage cheese produced in the country. For the Pacific area, 84.9 percent of all families buy creamed cottage cheese, with an average volume per family of 9.6 pounds during April-September 1954. This contrasts with a low of 31.9 percent of all families in the South with an average volume per family of 6.1 pounds for the same period.

We are constantly hearing specific examples of the effect of quality and merchandising on sales of dairy products. Recently I listened to the man in charge of butter sales for a Midwest chain store tell of how the chain's butter sales were based on U. S. Grade AA butter, with a complete check from factory to store, including a check on the age of butter remaining on store shelves.

I emphasize quality and merchandising in this connection because I seem to sense in some quarters a feeling or a hope that milk concentrates can be used to break down what some people call "barriers" or, if they are more considerate, they use the term "unnecessary sanitary requirements."

This difference that prevails in the generally accepted requirements for production and processing between milk for manufacturing and milk for fluid use could, of course, be eliminated by increasing the sanitary requirements for manufacturing milk.

I mentioned earlier that the Commodity Credit Corporation, during recent years, has had considerable experience with the taking of water out of milk. It should be emphasized that this experience has not been the result of any demands of the market place. Two factors have been important in this experience. One grew out of the wartime need for food. This led the Government to encourage farmers who had been selling farm separated cream to shift to the selling of whole milk. This trend has continued in recent years, and it appears that it may continue for a few more. During 1925, about 52 percent of the milk marketed by farmers was marketed as whole milk. By 1940, this percentage had increased to 62.

During 1950, of all milk marketed by dairy farmers 79 percent was whole milk; for the year 1954, the percentage was 85. This shift to whole milk was accompanied by a large increase in nonfat dry milk processing facilities. At the same time the wartime demands were so large that even nonfat dry milk that had been going to domestic commercial markets was taken to meet wartime needs.

But even with these conditions, with the decline in milk production after the war, the supply of nonfat dry milk was such that relatively small quantities of that product were bought under the price support program in 1951 and 1952. Price support purchases of all dairy products were relatively small in both 1951 and 1952.

The postwar slump in milk production ended during 1953. Milk production that year was almost 6 billion pounds greater than the previous year, and this was followed by another increase of over 2 billion pounds the next year. Thus far in 1955, total milk production has been slightly larger than during 1954.

Thus far present merchandising methods have not found a market for this additional milk supply. During the past five years there appear to have been no marked changes in the utilization of the total milk supply. There is some evidence that very recently fluid milk and cream may have improved their position slightly and that butter may be taking a somewhat smaller proportion of the total. But the changes, if any, have been small.

Another item that appears to be using a smaller proportion of the milk supply is evaporated milk. This product is probably closer to the kind of concentrated milk that this conference is concerned with than are such products as butter, cheese, and ice cream. If that is true, some guesses about evaporated milk may be worth while.

The first characteristic I will mention is probably not a guess. It is doubtful if any dairy product has been sold on the basis of brand name to the same extent that evaporated milk has been sold. One of my vivid memories of O.P.A. days is that of frantic mothers calling to find out where they could buy a specified brand of evaporated milk. And just evaporated milk would not satisfy them.

I have seen no satisfactory explanation of the apparent decline in the per capita use of evaporated milk. Two possibilities have been called to my attention. One is that the evaporated milk merchandisers have been out-merchandised by their own methods. Now mothers want not only a specified brand, but they want a specified brand of a product made specifically for feeding babies. And this despite the fact that the other product costs much more.

The other reason that has been mentioned is the much more general availability of refrigeration in homes and probably also a greater availability of fresh fluid milk.

One of the evaporators' reactions to the situation seems to be a vigorous campaign among themselves to sell "brands" of another concentrate, "instant nonfat dry milk solids."

In order to sell a product it is still probably necessary to convince the purchasers that the product has at least some small merit. How much merit the product must have in this age of packaging and box tops and of singing commercials, I am not sure. I will not be too surprised if some day a product appears that is sold entirely on the advantages and beauty of its package, with little concern with what, if anything, the package contains.

There are other factors that appear to influence the purchaser in spending his money. The Administrator of the Commodity Stabilization Service recently pointed out that:

> "This is an age of 'convenience foods.' Housewives today use 12 times as much frozen vegetables as they did a few years ago. They use 50 times as much frozen orange concentrate for making orange juice as they did only 8 years ago. Shortly after the end of World War II, one cup of coffee out of 16 served in American homes was instant coffee. Today, one out of 3 cups of coffee is instant coffee. The American housewife demands convenience, not only in the appliances and utensils she uses in her kitchen, but she demands it in the food itself. She wants to get extra service -- extra time saving -- extra quality -- extra nutrition -- and in all things, extra convenience. I have heard these developments referred to as 'built-in maid service.'"

Not only, under today's ideas of merchandising, must a product be convenient for the housewife, but it must be convenient for the marketing system. We seem inclined to adapt the product to the marketing system rather than attempt to make the marketing system adapt itself to giving us the best possible product.

I recall hearing of a California experience with the marketing of tree ripened peaches. A combination of research and extension work showed that it could be done both to the greater satisfaction of the housewife and the financial advantage to the grower. But the marketing of tree ripened peaches still seems to be too inconvenient for the marketing system.

Perhaps this partly explains the success of concentrated orange juice. But suppose the same effort had been put into the merchandising of tree ripened oranges as fresh oranges. This would not have solved the problem of convenience for the housewife. She probably prefers taking the top off a small can to taking the peel off an orange.

At the moment concentrated milk does not seem to have either of the advantages that probably helped to develop concentrated orange juice. Milk does not improve with ripening. Except possibly for pasteurization and homogenization, both of which are applied to whole milk, there appear to be no processes for improving the quality of whole milk as it leaves the cow.

If the cow is badly fed, carelessly milked, or the milk poorly handled, it may acquire flavors that can be removed by processes associated with high degrees of concentration. Under sufficiently intense competitive pressure maybe fluid milk distributors can find equally efficacious ways of ridding their milk of these flavors.

As for convenience in the household, it is still hard to find an easier way than merely pouring milk out of a bottle.

Recent history with concentrated milk is not encouraging. This, of course, proves nothing. Milk production has increased, and it seems likely that it will continue to increase. Any new products that can be developed should help in the effective utilization of this increased production. Perhaps the greatest loss from the emphasis on the new is failure to do what might be accomplished more rapidly by greater emphasis on improved quality and merchandising of the old. Perhaps both the old and the new should receive greater attention.

WHAT FORMS OF CONCENTRATED MILK ARE NEEDED FOR HUMAN CONSUMPTION?

by

Philip B. Dwoskin, Agricultural Marketing Service
Washington, D. C.

Innovation is a key element which makes our economy of today dynamic. Innovations in dairy products, specifically milk concentrates, are our main concern at this conference. The dairy segment of our economy is in the process of change today. Although the trend is moving rather slowly, there has been in recent years a breaking down of some of the restrictions on the flow of milk to the various regions of the country. Milk concentrates can help accelerate the breaking down of some of these barriers. This is particularly true for the problems of long-haul transportation of milk. The obvious inefficiency of transporting the water in milk over long distances has made milk an especially expensive item in areas where deficits in supply occur.

Another thing that milk concentrates can do is to make milk available to more consumers than at present. Milk concentrates afford a form of storage not now available for the most efficient animal protein food. Present methods of storage are inadequate to meet the needs caused by fluctuation and seasonality of production--inadequate in terms of fluid milk for beverage uses. Then there is the possibility of the export market for milk concentrates. Here, of course, the advantages of a concentrate are even more apparent than for the domestic market.

There is no doubt in my mind as to the importance of milk concentrates to the dairy industry and our economy as a whole. Neither am I in doubt as to the place that milk concentrate should have in our dairy industry. Milk concentrates inherently have almost all the characteristics needed to solve some of the major problems--production, storage, and distribution--facing our dairy industry today.

I

There seems to be little doubt that our productive capacity is sufficient to supply our food needs for the next several decades. Any current indication of Malthusian thinking as to population outracing our food capacity is almost nonexistent. Of course, as is true of all projections, historical

trends in income, population, technology, and capacity have to be assumed. In addition, the foreign scene has to be assessed and fitted into the set of assumed conditions. So if we can go along with these assumptions--and there is no valid reason for us not to--then we can assume that there will be enough food to meet our requirements in 1975.

Specifically, the projections for 1975 call for total domestic requirements for farm products at about 45 percent above the 1951-53 average. For dairy products, a more moderate increase is expected in consumption. The moderateness of the increase is based on the fact that although consumption of fluid milk per person is expected to rise at a higher level than for other dairy products, a lesser increase is anticipated for other dairy products which will moderate the rising trend for the fluid milk picture. 1/ This means, of course, that the future for milk concentrates can be said to be fairly good, since much of the thinking that has gone into the development of milk concentrates, both liquid and dry, has been in terms of use as fluid milk products.

Without too much claim for originality, I feel safe in predicting that the trend in food products available to consumers in the future will be toward more concentrates. Since much of the bulk of today's food products is water, the obvious gains from concentration in terms of transportation, storage, packaging, and distribution necessarily lead to concentration as the answer.

Some of the more interesting of the concentrates available today or in the near future have been developed right here at this laboratory and at the other utilization research laboratories of the Department of Agriculture.

II

Let us now turn to some of the work that has been done in the past in terms of market research on dry and liquid concentrates. Two of the products that are presently on the market, with which I have had some experience, are fresh concentrated milk, usually the 3-to-1 concentrate, and nonfat dry milk solids.

Fresh concentrated milk of the 3-to-1 variety was introduced into a number of Eastern markets in competition with standard fluid milk in 1951. Many felt that the introduction of the product would provide an opportunity for increasing the intake of milk solids and improving the nutrition of our population. It appeared that the major impact of the product would come in the interregional movement of milk, in view of the lower cost of long-haul transportation resulting from the reduction of weight and bulk by concentration. Substantial transportation economies were suggested by the possibilities of processing milk into concentrate in surplus producing areas, notably the Midwest, and selling in competition with standard milk in Atlantic and Gulf Coast markets. The actual situation did not quite reach the anticipation of those who saw the above potential far-reaching

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1/ "Long-Range Prospects for Agriculture." A paper delivered by Rex F. Daly, Agricultural Marketing Service, U. S. Department of Agriculture, to the National Agricultural Credit Commission in Chicago, Illinois, on June 6, 1955.

consequences of this new product. While initial sales of this product in some of the markets reached almost 5 percent of the total fluid milk sales, in a relatively short period, sales began to fall off. As sales continued to decline, the product was withdrawn from the Eastern markets. Today it is available in only a few localities.

The above is an old story to most of you and reasons for the failure of this product in the Eastern markets are also supposedly an old story. The decline in sales of this product was attributed to several factors. The first one, which most people seemingly have accepted as the most important, was the lack of a sufficient price differential. The milk used for concentrating was priced at the same price as regular Class I milk, thereby eliminating any price advantage over fluid milk. A second reason given for its failure was the lack of convenience of concentrated milk; that is, in spite of its space-saving features and versatility in use, it proved inconvenient for most housewives to reconstitute the product. Another reason for its failure was that the quality of the product in home use in some instances was a deterrent to its success. And, finally, the tacit opposition of some of the producing and distributing segments of the milk industry contributed to the failure of fresh concentrated milk. However, as mentioned previously, fresh concentrated milk is not altogether dead. It is still being sold on the Pacific Coast and has found a rather interesting market in rural home delivery. I believe that this aspect will be discussed more fully by Mr. Iverson of Iowa State College tomorrow.

The market research, including product testing, undertaken by one of the large dairy companies before the introduction of liquid concentrates was, in my opinion, well done. 2/ By this, I mean that the methodology, including the sample used and the analysis employed, met the high standards of good marketing research. But, since the product failed, perhaps the marketing research, despite its seemingly high standards, cannot be absolved from its share of the blame. Basically, all the reasons cited before as to the failures of milk liquid concentrates can be found in the replies of respondents in the surveys undertaken in the several markets. The need for lower prices (that is, lower than standard milk); the inconvenience of reconstituting the product; the need for keeping chilled water in the refrigerator, which cancelled out the space-saving features; and the complaints of some of the respondents as to the flavor of the product--all of these problem areas can be found in the market research results. However, not having the benefit of hindsight, none of these reasons bulked large enough percentage-wise to indicate to the analyst that the product would not gain consumer acceptance. The study results show that most of the respondents in these surveys felt that fresh concentrated milk was a good product and most indicated that they would buy the product if it were put on the market. Of the unfavorable comments, few were directed at the taste or quality of the product; most were directed at the inconvenience of mixing, the need for a special container for mixing, and its possible price. Those respondents who had an opinion as to the price at which the concentrate should be marketed said that concentrated milk should sell for less than regular or standard milk. Admittedly, with these facts in mind, the

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2/ Unpublished market research studies involving household panels and market tests prior to the introduction of fresh 3-to-1 concentrated milk in 1951 were made available to the author.

decision to go ahead and market the product constituted somewhat of a gamble, yet it was the kind of calculated risk that most firms must take in marketing a new product.

It is my opinion that too much blame for the failure of concentrated milk has been attached to the lack of price differential between the concentrate and regular milk. The question really lies in whether or not you can actually pay the housewife enough to make her work harder. This I doubt. With the trend in the food industry toward more and more convenient items, such as cake mixes, the convenience aspect cannot be over emphasized. The success of higher priced instant nonfat powder because of its added quality and convenience is further evidence of the importance of attributes other than price.

Many of these convenience products are higher priced than the ones they are competing with. Yet the convenience is such that the price becomes a less vital factor in the decision of the homemaker whether or not to buy the product. It is my belief that the lesson to be learned from the failure of milk concentrates is not in its pricing but in its actual lack of convenience. The factors of convenience attributed to the product, that is, its space-saving features, versatility in use, etc., did not turn out to be conveniences in household use. The need for the product to be refrigerated and reconstituted, its relatively short shelf life, the large size of the container, and the need for extra mixing equipment and chilled water counterbalanced whatever convenience aspects the product originally had.

To summarize the experience with the liquid 3-to-1 milk concentrate, one must consider the background of its competition. The new product was up against a product which has been sold to the consumer through years of education and promotion. Standard fluid milk is an excellent product, it is packaged attractively, it has excellent flavor and quality, and it is convenient to use. One can say that even with a favorable price differential the product would have had rather tough sledding in gaining consumer acceptance. In my opinion, the determining factor in concentrated milk's marketing failure was its inconvenience in use and storage. Or, turning it around another way, one can say that the lack of a price differential became more important as the convenience aspect turned out to be less of an attribute than originally determined.

The story for nonfat dry milk solids is a much happier one than that related for the liquid 3-to-1 concentrate. The statistics published by the American Dry Milk Institute show a steady increase over the past 5 years in the home use of nonfat dry milk solids. 3/ Using our household purchase data as a basis for projecting the sales of nonfat dry milk solids for 1955, we find a substantial and continuing increase for 1955 (20%) compared with 1954. 4/

The question arises: How has this increase in household purchases of dried skim milk come about? Is it the same purchasers buying more at a time? Are they buying the product more frequently, or are new buyers coming into

3/ 1954 Census of the American Dry Milk Institute.
4/ Household purchase data obtained from the National Consumer Panel of the Market Research Corporation of America.

the picture? The data indicate that the consumer base has broadened. The proportion of families buying nonfat in 1955 compared with 1954 has increased about 23 percent. In addition, the 1954-55 comparisons are of special interest because it was in October of 1954 that national distribution of the new instant milk became an accomplished fact. In other words, the introduction of instant dried skim milk has been a considerable factor in broadening the base of concentrated dry milk users. This fact is an optimistic harbinger for the future. It is also interesting to note that the price of instant dried milk has been approximately 4 cents higher than that for the usual type of nonfat dried milk solids and that, in spite of this higher price, sales have gone up substantially in the last year.

We did some intensive work on nonfat dry milk solids in Memphis, Tenn., in 1952 and 1953 in attempting to study the effects of nonfat dry milk solids on fluid milk consumption in households. 5/ The utilization pattern for this product in Memphis households was found to be mainly in cooking and baking. In terms of actual amounts purchased most of the solids were used in the above two categories. Only a very small proportion of the users said the purchase of nonfat dry milk solids eliminated the use of fresh milk in their households. Of course, this work was done before the instant powder became available. It is quite likely that instant powdered milk may have changed the utilization pattern we found in Memphis. That is, we would expect a greater switch to beverage use.

Another interesting fact, which came out of our work in Memphis, is that when householders were asked to make comparisons as to the food value of nonfat and fresh milk, most users and nonusers of nonfat dry milk solids felt that nonfat had less food value than fresh milk. The interesting feature of this particular comparison was the reason given by housewives as to why nonfat had less food value than fresh milk. The predominant reason among both users and nonusers of nonfat dry milk solids was that nonfat dry milk solids did not contain butterfat. It is interesting to speculate as to how many more households could be brought into the market if a comparable dried whole milk product became available.

III

There are a number of concentrated milk products on the market today. We are well aware of them and the need for discussing them is of only academic interest. In the dry nonfat milk concentrate field we have, of course, the regular type product and the new instant variety. In addition, there is a dried whole milk product available commercially today. In the liquid concentrate field we have the usual canned evaporated and condensed milk. We also have the fresh 3-to-1 milk concentrate, which is sold in a few scattered localities. There is also a canned sterile whole milk. Sales of this product have for the most part been confined to the export market. Within the recent past a liquid concentrate in cans, known as "fresh-tasting" evaporated milk, has been introduced in several test markets.

5/ Dwoskin, Philip B. "Milk Products--Consumer Patterns and Use, Memphis, Tenn." Marketing Research Report No. 39, Bur. of Agr. Econ., U. S. Department of Agriculture. May 1953. Also: Dwoskin, Philip B., Bayton, James A. and Hoofnagle, William S. "Changing Patterns of Milk Consumption in Memphis, Tenn." Marketing Research Report No. 69, Agr. Marketing Service, U. S. Department of Agriculture. June 1954.

The many news stories of the past several years concerning the impending commercial readiness of a frozen concentrated milk make a few observations on this product pertinent at this point. Because of its relatively greater inconvenience in reconstitution compared with the liquid 3-to-1 concentrate, some in the dairy industry have written off frozen milk concentrate for household use. The frozen concentration method, however, is recommended for bulk storage of milk. 6/ On the other hand, there is a convenience aspect of this product for household use that deserves consideration. It is estimated that 20 percent of our households now have some freezer capacity. Milk is one of the few foods not now available to the housewife for freezer storage. Furthermore, with the trend toward complete once-a-week shopping, a frozen concentrated milk product would neatly fit into this pattern.

All of these aforementioned products have a place in our marketing system and in household use. They undoubtedly will be used in increasing amounts over the future. However, none of them in its present stage of development is the answer to what the consumer wants or needs in the form of milk concentrates.

IV

Now let us take a look at some of the barriers facing the introduction of a new milk concentrate. Before we do this, first let us examine some of the implications of a new milk concentrate to the dairy industry.

The consumer, of course, is the end user and in the last analysis will determine the success or failure of a particular product that is offered for sale on the retail market. Yet the ramifications of the effects of a new milk concentrate which would actually meet consumer wants are of tremendous importance not only to consumers but also to producers, processors, and distributors in our dairy economy. Let us imagine, for instance, that a competitive concentrated liquid or dry whole milk of high quality is developed. By this I mean a product which has the fresh flavor, stability, convenience, and the ability to compete on a price basis with the present fresh fluid milk. The change in our marketing system which could arise from such a development is tremendous in scope. A few implications are obvious. Our whole pattern of milk production in the last few years has been aimed at reducing the seasonality of supply. If a storable whole milk product were developed, the problem of seasonality of supply of fluid milk and high cost of production during the winter months would be reduced. The adaptation of manufacture to different conditions might change some of our present geographic patterns of production or processing. Problems of storage, transportation, and refrigeration would become minor compared with those existing currently on fluid whole milk.

But what does this mean to you physical scientists? In many respects, the trend toward milk concentrates, dry or liquid, awaits technological developments. Milk concentrates are by no means new products. Work on this type of development has been going on for many, many years. Many of the products developed have had excellent quality, fresh-flavor taste, convenience,

6/ Bell, R. W. "Factors That Affect the Stability of Frozen Concentrated Milk." June 1955. A paper presented at a symposium on concentrated and dried milks at the American Dairy Science Association meeting, Michigan State University, June 1955.

and economy, but in no instance has there been a product developed which has had all of the above-mentioned attributes combined into one product. While it is simple to list the attributes of a milk concentrate needed to meet consumer wants, the barriers ahead are tremendous. One group of barriers is technological in nature. The problems of protein stability, fresh-flavor transfer, shelf life, and high solubility are well known to most of you. These problems will be discussed in detail later in the program. But other types of barriers also face the widespread adoption of new milk concentrate products. These barriers can be classified in many ways--consumer, institutional, psychological, etc.

Much as I would like to say that I know or I have a pretty good idea as to what kind of milk concentrate is needed for human consumption, you know as well as I that at best it still remains an educated guess. We market researchers like to think that we know something about the consumer, but, unfortunately, the consumer still remains somewhat of a mystery to most of us. However, the lack of information on consumer wants is only part of the story. The dairy industry, as many of you know, is a complex one and, as a consequence, there are many conflicting interests in the industry itself. As you know, there are producers for the fluid market as well as for the manufactured products market; there are surplus areas and there are deficit areas. Concentrated milk is advantageous to some in the industry, and not so advantageous to others. In addition, there are the health codes and other restrictive measures which hamper the free flow of fresh milk from one area of the country to another.

Then we have what I term the psychological barrier to the introduction of new milk products. To many consumers tampering with milk is akin to tampering with the Bible. We know that most milk consumers are aware that milk is a healthful, sanitary product. Market research has in the past substantiated this fact very clearly. As far as consumers are concerned, the fluid milk now available to them is an acceptable product. It has good flavor, it is attractively packaged, and it is convenient to use. In addition, there are many milk distributors who will contest the fact that fluid milk is too costly to the consumer. All this means is that the consumer is not awaiting with a palpitating heart new products developed from milk, as some people might think. Or, putting it another way, a successful concentrate will need to be a product combining not only price gains to the consumers but one of high quality, with a flavor characteristic of fresh milk and, at the least, the convenience of fresh milk.

V

In conclusion, I would like to attempt to answer the question assigned to me by delineating the characteristics a milk concentrate should have to gain consumer acceptance. As to the kind of milk concentrate, I would unhesitatingly select a whole milk concentrate. Such a product, liquid or dry, should have the following necessary characteristics for commercial success. First, the product has to be convenient, and convenience can be achieved by a combination of (1) reduction of bulk, (2) long shelf life with or without refrigeration, preferably without, (3) easy reconstitution in any amount desired, (4) availability in a variety and appropriate size packages, and (5) versatility in use. I want to emphasize the importance of convenience for any new food product being developed today. In the dairy industry's

competitive struggle to maintain or increase its share of the consumer's food dollar, convenience is the crucial factor. A look at the food items on our grocer's shelves is convincing evidence on this point. A second major attribute of a whole milk concentrate should be quality. For this attribute I would list the following: (1) The product should be stable before and after reconstitution; (2) it should be at least as sanitary as fresh milk; and (3) it should have the flavor of fresh milk. Included in this flavor aspect is flavor stability; that is, the flavor should be consistent within a given brand and if possible between brands. This means rather strict standards or grades for the raw material to be used for processing. A third, and probably to some the most important, attribute of such a milk concentrate is price. I have purposely listed this attribute last because I am convinced that if you can achieve the first two major attributes--convenience and quality and flavor--price is not necessarily the all-important factor. However, the price should be less than that of the original product--fresh milk.

I do not believe that a whole milk concentrate can possibly command a price premium as that found for such convenience items as cake mixes, which, in addition to the usual ingredients, include higher priced ingredients. Furthermore, even the ideal concentrated whole milk product will not have the convenience gain potential of the new cake mixes. Therefore, the relative price of a milk concentrate becomes more important as an added attraction in selling the product. Thus, a favorable price differential for the new concentrate compared with fresh milk is highly desirable. Despite what has happened in the past, such a favorable price differential for concentrate is feasible since substantial price differentials exist between surplus and deficit areas and between Class I and manufactured milk, to permit a competitive price range between milk concentrates and fresh milk.

The above summarization of the characteristics of a milk concentrate needed for human consumption does not include anything that you are not already aware of. On the other hand, I am sure that most of you recognize that to combine such attributes into one product is a task which, to say the least, is a difficult one. But from my close association with physical scientists, I am sure that such a product eventually will be developed and that it isn't as far off as some people might think.

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Discussion

C. S. Kauffman: Would you object if I interject a controversial point?

Dr. Wells: We would love to have any type of point brought out at this moment.

Kauffman: First of all I am simply amazed that a group of this kind, headed by Don Anderson, who is director of this extension, neglect the consumption of milk and chocolate milk for home use. Not one mention has been made of one of the biggest areas for the consumption of milk that there is. Milk is a beverage. I am going to go back a little bit; about 3 years ago I didn't know anything about milk except you drank it once in a while when you got it. In working with the military, one of the heads of the Navy statistics said, "Why in the world can't you do something with concentrated milk?" I said, "What's the trouble, Bill?" "Well, you know the Surgeon General has cut back because we haven't any good method of reconstituting."

The interesting thing is that when we took a look at the industry, I found that in all my marketing experience I had never seen anything so dead as the marketing in the dairy industry; so obsolete, so far behind the time and so lacking in originality. Well, that't the bomb shell that I want to put in first.

I consulted some of the top flight men in the Department of Agriculture. When you come to the matter of reconstituting milk, do you know what their list is? 89 obstacles--not one thing you can do, but 89 that you couldn't do. But you don't care about what you can't do when you are trying to do something. The next thing, I made a survey of the industry itself, and it was literally amazing how resistant the industry is to new ideas. I finally went around and I found Dr. Herreid and I found Dr. Iverson and the crowd out there in Wisconsin, who were working on concentrated milk to some very good advantages. Never, however, has anything in particular been done for the consumer, the man or the person who drinks milk with his meals; coke has gone up, coffee has gone up, soft drinks are way up there. You take the men in the military. In the Army, the men have a preference to milk of three to one over coffee, yet you have rationed allowances that allow the men to have all the

coffee they want and right today they are building up ration allowances that practically take the milk that they now have away from the men.

And now getting back to some of the things we have been talking about - we actually developed a unit which is going into production, and I don't know that I should mention it here, but I just wanted to tell you; first of all, there is some very excellent quality concentrated milk today that is grand. As far as selling milk to the housewife as a beverage is concerned, I think that the marketing has been amazingly clever. You brought out here today that there is a lack of convenience. You can't expect a woman to take a quart of milk into a home, put it in a gallon jug and mix it; that's so nonsensical it is terrible - whoever thought a woman would do that just never looked at the market. If each woman got a bottle of concentrated milk that was divided into three parts, then at least you can take the one-third off and put it in the quart bottle and mix it, and then you can take another third off and put it in a bottle and mix it, and the last third you can leave in the bottle and mix it. Now there is a clever idea of marketing - now that happens to be homewise, but actually as to selling milk as a beverage to the consumer, there has been practically nothing done.

I would like to suggest to you folks here - start moving in getting uniform standards of concentrated milk, and by the way there are none. Some is good, some is lousy and some is excellent. I certainly would suggest that you people in your discussion would start thinking in terms of milk as a beverage. When the boys come out of the Army - about a million a year go in and a million a year come out - and they prefer it 3 to 1. They can't find any milk at any of the installations, the only place they can get it is at home. Then they go back to coffee because we have what we call a coffee hour. This idea that concentrated milk has no potential - it's just wrong from beginning to end. The potentials are terrific, they are right at the door, the opportunities of reconstituting are there, it can be done and it could be an excellent product. Iverson has one of the finest examples of frozen milk you could want; Herreid has done a good job. I would like to see you discuss something besides milk for the home. Incidentally, Westinghouse refrigerator has a little unit that will take concentrated milk and reconstitute it - it does a peach of a job. Women are asking why they can't get reconstituted milk in the PX's. Despite the fact that they are trying to throw out the PX's, they still exist. It is a big market. Sorry to keep this controversial.

Dr. Wells: We appreciate your comments, Sir. In the numerous introductions that were made, in fact I am not sure that you were here when we introduced ourselves, I didn't get your name.

Kauffman: C. S. Kauffman, of C. S. Kauffman and Associates, Washington, D. C.

Dr. Wells: I think it is always helpful to have someone who doesn't know anything about milk look in on the situation. I might say that we have a corresponding picture here in this laboratory. About four months ago when we undertook some work we selected a group in our engineering division who knew nothing more about milk than that you drink it occasionally, but they are a group that do know something about drying of heat-sensitive material, they do know something about milk now, too. Does anyone have any further comments?

Question: I'd like to ask Mr. Dwoskin a question. In these problems that you mentioned, of marketing a fluid concentrated milk in the East, was there a differential between the concentrate and the fresh milk? Did it exist all during the period of the trial?

Mr. Dwoskin: Initially, there was a price differential in favor of liquid 3-to-1 concentrate over regular milk. In the Eastern market, a quart of concentrate sold at 4 to 6 cents less than an equivalent amount of regular milk. In some other markets, particularly the Pacific Coast, there has been, and I believe continues to be, a price differential of 6 to 9 cents in favor of 3-to-1 liquid concentrate. The price differential came about because processors were paying manufactured rather than Class I prices in most instances for the milk used for concentration. This differential was eliminated when it was ruled that processors had to pay Class I prices for milk used for concentration. Thus, in many markets for most of its commercial existence, liquid 3-to-1 concentrated milk did not have a favorable price differential compared with fresh milk.

Dr. Patton: Mr. Dwoskin's emphasis on frozen food channels as a means of distributing milk products appeals to me; in fact I have a kind of pet issue along that line. Many of our products when stored at room temperature suffer from the effects of the previous heat treatment. For instance, dry whole milk is quite good when it is first manufactured, but it is the early storage period when it's held at room temperature when it begins to suffer its main flavor deterioration. For this reason I wonder if we can't try to visualize something like an instant dry whole milk held at freezing temperature, distributed like frozen orange and just like the orange juice taken from the freezer and popped into a pitcher of water at the breakfast table, and swirled up and we have our milk. I realize that there are probably some factors that have bearing on this problem that I haven't brought out, but I do think that we should be looking in the direction that Mr. Dwoskin has amply brought out.

Dr. Wells: Dr. Patton has an extremely good point. Certainly based on our experience with whole fruit juice powder our storage data would indicate that this would be a very desirable procedure. What we would like to attain would be sufficient stability that you could get away with room temperature storage.

Dr. Patton: I think you could get the stability if you could get the temperature low enough immediately after manufacturing.

Don Anderson: I think that it's the convenience in merchandising that counts. We will produce the product and it's men like Dwoskin that will have to find a way of selling the product. I think that we are all together on this. Dairy products in the main have been made hard to get rather than easy.

Mark Keeney: I think that you cannot overemphasize this problem of flavor quality in concentrated milk. I know that the claim was made a few years ago that the flavor of that product, 3-1 concentrate, was comparable to fresh fluid milk. The product that I tasted on the Washington market was not comparable in flavor to fresh fluid milk. It was good, it was a very excellent concentrate, but it could not compete in flavor quality with fresh fluid milk.

Kauffman: There are tests made on concentrated milks and on Mr. Iverson's milk sent to the Department of Agriculture by top taste experts. They rated the milk better than the regular homogenized milk from the local dairy. So the flavor is there. When you concentrate milk right, you get rid of the so-called dairy flavor or smell. When you reconstitute right, you will get an acceptance of 7 - 10 preference over the homogenized milk from the same dairy.

Dr. Wells: You've got to get the cow out of the cow's milk.

Comment: In a test panel of non-experts at Pennsylvania State, 75% could pick out the reconstituted milk and did not prefer it.

Mr. Brighton: We ran into the trouble of local water supply in the case of reconstituting orange juice, and this might be an important factor in the reconstitution of milk. You cannot use bad water and get a good product.

TYPES OF NONFAT DRY MILK REQUIRED BY THE FOOD MANUFACTURERS

by
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Chicago, Illinois
(Presented by Robert Osborn)

The American Dry Milk Institute greatly appreciates the honor of appearing on this program. Since the subject assigned was so inclusive, we have decided to limit our remarks to the subject of the uses of nonfat dry milk in the food industry with particular emphasis on the requirements for special or tailor-made products for specific purposes. The dramatic and almost spectacular increase in sales of home packages of nonfat dry milk tends to make us forget that the great bulk of sales of nonfat dry milk is to commercial users. In 1954 only 8.25% of the nonfat dry milk produced was sold in consumer packages. Perhaps a better understanding of our problem of producing nonfat dry milk for specific end uses may be had if we consider first how we disposed of the 1.4 billion pounds of nonfat dry milk produced in 1954.

We use the word "disposal" rather than "sales," because a little more than 47% of our total "disposal" was to the Commodity Credit Corporation for support purposes, and a total of approximately 52% was procured by all government agencies. This makes the government our largest customer. We are sure that neither Don Anderson nor our industry wants it this way. Perhaps by meetings of this kind--reviewing where we are technologically--we may be able to help solve our problems. Briefly, during 1954 we disposed of 47% of our available supply to the Commodity Credit Corporation, 46% to domestic markets, 5% to school lunch programs, 1.7% to export and 0.3% to the U. S. Army Quartermaster. It should be pointed out, however, that during 1954 more nonfat dry milk was sold to the domestic market than in any other year of our history. This is based on recently released U.S.D.A. figures.

For the purpose of our discussion today, we wish to consider these markets individually. What are the known requirements for these markets from a standpoint of "tailor making" nonfat dry milk?

The Baker used during 1954 roughly 38.4% of all the nonfat dry milk sold in the domestic market. For bread, he specifically requires a nonfat dry milk which has been heat treated sufficiently to inactivate the loaf volume depressant factor present in raw milk.

It is well known that inadequately heat-treated milk or dry milk prepared from it has a very material effect on the quality of bread baked in a commercial bakery. The dough is sticky and difficult to handle in bakery equipment. When such milk is used in the normal amounts of 3 - 6%, it can sometimes cause stoppage of the production lines in the bakery. Further, the bread produced is low in volume, compact in texture, and tough in eating qualities. Improperly heat-treated nonfat dry milk is, therefore, not satisfactory for bread baking purposes.

Unfortunately, we do not know as yet what the loaf depressant factor is. In 1929 we established a research fellowship to study this factor with the hope that it could be identified and a test could be developed which would

be suitable for the purpose of setting standards for bakery type nonfat dry milk. This fellowship is still continuing. While we have learned much of the chemistry of milk and the effects of heat upon the various constituents of milk, the specific factor has eluded this research.

However, certain basic facts have been established as a result of this work and other research carried out concurrently. These findings have enabled our industry to produce nonfat dry milk of satisfactory baking quality. As examples:

(a) Nonfat dry milk solids, manufactured by preheating the raw milk sufficiently to destroy the "loaf depressant" factor prior to drying, will produce a better loaf of bread than can be produced with no milk solids, from the standpoints of nutrition, physical appearance, internal characteristic, and taste appeal.

(b) It has been shown that the minimum heat treatment necessary to destroy the "loaf depressant" factor is 165° for 30 minutes, or its equivalent. In practice, however, a preheat treatment of 185° for 30 minutes, or its equivalent, allows ample safety factor for plant operations.

(c) When raw separated milk is preheated to temperatures in excess of approximately 155° for 30 minutes prior to drying, the soluble whey protein fraction is denatured. The amount denatured is dependent upon the time and temperature of heating and to some extent also on the heat sensitivity of the whey protein fraction.

(d) Several tests, such as the Harland Ashworth test have been developed for measuring the nitrogen content of the residual whey protein of nonfat dry milk. The Harland Ashworth test in particular is being used by many of our drying plants to check their plant processing.

(e) Although the amount and heat sensitivity of whey proteins in unheated separated milk varies somewhat, the variances within a given plant are relatively small. Therefore, once a plant has determined the nitrogen level and the sensitivity of the whey protein of its raw separated milk supply, positive control for bakery use can be maintained by determining the amount of nitrogen present in the whey protein of the finished product.

(f) The same type of pre-heat treatment is required for both roller- and spray-processed nonfat dry milk. Apparently the heat treatment received by cold, raw milk as it flows into the well between the rolls is not sufficient to assure its good baking quality.

The dry milk industry now has, and has had for a number of years, all of the knowledge and controls necessary to produce a satisfactory "high heat" or "bakery type" nonfat dry milk. Since 1951 the American Dry Milk Institute has recommended and sponsored the adoption of the plant procedures outlined above. Because the nitrogen of the whey protein in raw milk varies in amount and heat sensitivity, it has been difficult to set acceptable standards or specifications for bakery type milk on this basis. At the present, in order to insure good baking quality, the maximum nitrogen limit for whey

protein would have to be set at a low level such as 1.0 or 1.4 mgm. per gm. However, an appreciable amount of milk whose baking quality is good has more nitrogen than this in its whey protein. If the specific "loaf depressant" factor could be identified and measured, the problem would be simplified. Stocks of nonfat dry milk such as the Commodity Credit Corporation has on inventory could be easily segregated and that found to be suitable used for baking purposes.

To illustrate this point: When the present Quartermaster Specification MIL-M-1495 was written in 1952, there were established levels for whey protein nitrogen of 3.5 and 5.0 mgm. per gm. for "high heat" and "low heat" respectively. In 1954 the requirement for "high heat" was changed to 2.5 mgm. per gm. We would have preferred recommending 1.0 mgm. per gm. for "high heat" and 6.5 mgm. per gm. for "low heat." Experience has shown that at times even the liberal levels of the specification cause hardship in some areas of the country.

Before leaving this topic we wish to emphasize that while we do not have any specifications adopted for bakery type nonfat dry milk, we have the knowledge required for making this type of product. The chief requirement is adequate heat treatment.

The Dairy Industry in 1954 was the second biggest domestic user of nonfat dry milk, approximately 20.3%. Although it is not possible to break down completely the individual usage in this market, we know that ice cream, cottage cheese and other types of cheese, buttermilk, and chocolate drinks used the major portion.

The use of nonfat dry milk in dairy products is a natural growth of the phenomenon of shortages and plenty throughout the dairy industry. When local supplies are low, it is necessary to import some form of milk solids to provide the raw materials to maintain constant supply. For example, the cottage cheese industry in the South ten years ago flourished during the summer months, but because of lack of nonfat solids, virtually disappeared from the retail market. Nonfat dry milk became a source of supply which could stabilize a profitable market. It was soon found, however, that all nonfat dry milk would not produce a satisfactory cottage cheese. The major defects included (1) inability of the reconstituted milk to develop sufficient acidity, and (2) poor whey drainage of the curd which resulted in soft, mushy curds that were unsalable.

Poor activity of nonfat dry milk is not just an "old wives' tale." Nonfat dry milk sold for cottage cheese, buttermilk, and cheese starter should be routinely tested for starter activity. For this purpose we recommend the use of the Elliker and Horrall activity test. The control of production is relatively simple once the test has been set up in the laboratory, but running down the cause can be extremely difficult. This is particularly true if the cause is small amounts of quarternary ammonium compounds. The problem of inadequate drainage of the curd is related to heat treatment.

We have discussed processing procedures and available control for "bakery type" or "high heat" nonfat dry milk. For the cottage cheese industry, it is necessary to produce another tailor made product, a dairy type or "low heat" nonfat dry milk.

From the standpoint of the Institute's recommendations, low heat nonfat dry milk is that product which has been produced under such conditions that the total heat exposure has not denatured more than 5% of nitrogen in the original whey protein of the unheated separated milk. This in effect means that the total time and temperature of heating, including that in the vacuum pan, is not much more than that of pasteurization. Again, the Harland Ashworth method can be used for control purposes within the plant. Since the maximum preheat treatment approximates that of pasteurized milk, we believe that "low heat" nonfat dry milk should be phosphatase-free to eliminate any question of the adequacy of pasteurization.

We realize that the measurements of starter activity and the precent of denaturation of whey protein do not fully take into account all of the desirable properties nonfat dry milk should have for the production of cottage cheese. Certainly curd tension measurements deserve to be considered. The dry milk industry is still in need of methods which can be used for setting up standards at least for "high heat" and "low heat" milk in absolute terms.

Except for cottage cheese,the dairy industry can use either "high heat" or "low heat" milk or one of "medium heat." For buttermilk there are probably some advantages to "high heat" but the reconstituted milk is usually pasteurized at high temperatures before culturing, so that double heat treatment is not essential. For chocolate drinks and ice cream the preference is usually for "low heat" or "medium heat." Some ice cream makers require superheated nonfat dry milk. This type is produced by superheating the condensed milk with steam prior to drying. The superheated nonfat dry milk will produce mixes of higher viscosities than other forms.

During 1954, there was distributed for final review before publication a tentative draft of the U.S.P.H.S. "Ordinance and Code Governing the Sanitary Control of Dry Milk Products Used in Grade A Pasteurized Milk Products." After these standards are published,it is believed that some of the existing barriers to the use of nonfat dry milk in fluid milk products will be eliminated. It is probable that the adoption of U.S.P.H.S. standards will lead to eventual increases in the use of nonfat dry milk by local dairies to augment their milk supply.

The small package nonfat dry milk represented 19.7% of our domestic sales or 8.25% of total production as reported earlier. Since Mr. Dwoskin covered this earlier, our only comment is that except for the small baker, small dairy, or institutional trade, and possibly the packaged dry mixes, we do not believe that "instant" nonfat dry milk will have many commercial uses so long as it is a more expensive product. Institutions should be a good market for this type of nonfat dry milk.

Our next largest market is the meat packer, who bought 9.4% of our domestic sales in 1954. When nonfat dry milk is used in sausages, meat loaves, bologna, frankfurters, etc., these products retain their fresh appearance, are juicier, and in many ways are superior to all other meat sausages. However, the Department of Agriculture, through the Meat Inspection Branch, ARS, limits the use of nonfat dry milk in sausage to 3.5%. In addition, the standards for "approved" sausage include nonfat dry milk in the category of stabilizers, gums, etc.

Historically, the use of nonfat dry milk increases as the price of meat increases. This trend is apparent today as we have had continual decline in tonnage in that market since 1952.

Although nonfat dry milk has been used in various meat products, only a rather cursory study has been made of the advantages and disadvantages of various types of nonfat dry milk. Preliminary studies were undertaken by the A.D.M.I. Laboratory last fall. These included comparisons of "low heat" and "high heat," spray process and roller process, made from cold milk and from milk which had been properly preheated for bakery purposes. We were unable to demonstrate any advantage of one type or process over the other. Unfortunately, the levels of fat, moisture and nonfat dry milk addition were all within the existing U.S.D.A. standards. It is possible, by increasing fat, moisture, or both above the present standards, to show greater absorptive properties of one type over another. Although strict standards are set for sausages, there are a number of meat products, including all of the meat loaves, which could take advantage of any developments along these lines. We plan to continue our work on the use of nonfat dry milk in sausages.

Prepared dry mixes represented 6.7% of our domestic sales. In our baking laboratory, we attempted to show differences in dry cake mixes between "low heat" and "high heat" nonfat dry milk. We were unable to find any significant difference. One of the problems we have encountered in the use of relatively large amounts of nonfat dry milk in dry cake mixes is the relatively low vapor pressure of nonfat dry milk as opposed to the relatively high vapor pressure of flour and other ingredients of the mix. This has resulted in apparent staling of the dry mix on the shelf. Nonfat dry milk solids with its lactose in the hydrate form could be the solution to this problem.

Other markets, which represent 5.5% of our total domestic sales, include confectionery, institutions, soup, pharmaceuticals, soft drinks, etc.; they have few if any special requirements. There are specific requirements for a few items. For example, "high heat" spray process nonfat dry milk is used in sterilized milk drinks, and generally roller process dry whole milk is preferred to spray for use in chocolate coating.

Thus, approximately 78% of our total domestic sales of nonfat dry milk during 1954 were to markets requiring tailor-made products. This tonnage, however, represents only a little more than 36.0% of all of the nonfat dry milk "disposed of" during 1954 if we include all Government purchases and commercial exports. Just how much of our total production could be "tailor-made" today with "high heat," "low heat," or "instant" is not known. Practically all plants today are equipped to produce "bakery type" or "high heat" nonfat dry milk. A smaller number of plants is equipped to produce "cottage cheese" type milk, and only a few are making the "instant" type products.

For many uses, the requirements for nonfat dry milk have not been as well defined as for the bakery type product. Our present problem is to determine these requirements, develop laboratory tests for their evaluation, and finally establish standards or specifications for the manufacture and purchase of the specific type of product needed. Our Institute through our

Research and Standards Committees is actively working on this problem. We welcome any suggestions in its solution.

Discussion

To Dr. G. F. Somers' question about the best stage at which the heat treatment should be made Mr. Osborn stated that heating before concentration is preferred.

Dr. Jenness pointed out that the heat effect on destabilization of the caseinate is faster on the concentrated nonfat dry milk. Denaturation of the whey proteins does not differ much whether heated before or after concentration.

THE METHODS AND PROBLEMS FOUND IN THE PRODUCTION OF CONCENTRATED MILK

by

Victor Nelson, Food Machinery & Chemical Corporation
San Jose, California

The methods used in the manufacture of concentrated milk are well known; the problems are less well known. However, I should like to discuss the production of evaporated milk from the manufacturer's point of view, confining my remarks largely to the heat treatment of milk, the problems found, and the methods which are used for their solution. Obviously I cannot cover the entire subject but I hope to show that the processing of milk has an interesting technical aspect.

Properties Desired in Evaporated Milk

It is probably appropriate, before discussing the methods of production, to describe the physical properties desired in a can of sterilized evaporated milk. While there is some variation of opinion, I believe most will agree (1) that the milk must be free from visible coagulation, that is, small specks of coagulated milk; (2) that a color and viscosity comparable to cream is desirable; (3) that the milk should not feather or coagulate in hot coffee; (4) that the milk should filter readily through the usual fresh milk filter pad. In addition, the inside of the can should be clean, that is, no "burn-on" or "smear-on." These terms apply to coagulated protein adhering to the can walls. "Burn-on" refers to coagulated protein with a foam-like structure adhering to the can walls in irregular patches, while "smear-on" consists of a thin coating of coagulated protein spread uniformly over the can walls. The milk should have also good storage properties, that is, fat separation should not be over a trace after three months storage at 75°F.; mineral precipitation (calcium citrate) should be absent; and no sedimentation or gelatin of protein should be evident. No unusual flavors should be present.

Hot-Well Procedures

I believe you are all familiar with the general plan of operation of a condensery. There are problems connected with every phase of the operation,

but none are more important than those found in the heat treatment of milk in preparation for canning and sterilization. While the difficulties appear in the sterilization process, the adjustments or corrections are made to a large extent in the hot-well process.

As a generalization, we might say that the variables in hot-well treatment are (1) the temperature to which the milk is heated, (2) the time required to attain that temperature or the rate of heating, (3) the time the milk is held at the desired temperature, and (4) the degree of agitation. There is considerable difference of opinion on the importance of these variables. It is true that equal importance cannot be attached to all of them and their relative importance will vary with the milk composition.

Jacketed Hot Well

To illustrate these variables, I should like to discuss some of the hot-well processes which are used. For example, milk is heated in the jacketed hot well at a relatively low rate and with relatively low agitation. A low rate of heating allows for salt precipitation and perhaps reduction in calcium ion concentration before that temperature is reached at which denaturation of the whey proteins begins. In some cases this may be a deciding factor in the heat stability, for there is some evidence of a practical nature which suggests that if the whey proteins can be denatured without too much loss of charge the heat stability will be improved. This idea may be incorrect, but the fact remains that heat stability is influenced not only by the time and temperature but also by agitation and the rate of heating.

Superheating Process

In marked contrast with the jacketed hot-well process is the so called "superheating process." This is a high-agitation, high-rate-of-heating, short-time-of-holding process which produces a gelation or coagulation in the unsterilized milk. It is used occasionally, usually with modification. There is high agitation with large surface areas. We can also expect relatively high calcium ion concentration and a high concentration of undenatured whey protein. If the process is continued for several hours the result is an unsterilized evaporated milk with a viscosity comparable with sterilized evaporated milk. Obviously, the process is not continued but the point is that the manner of heating can have a very marked influence on the physical properties of the milk. These two processes represent extremes, but you can readily see the opportunities offered for innumerable variations in hot-well treatment.

Tubular Heating

The hot-well process most commonly used in the evaporated milk industry employs tubular heat exchangers for heating milk to the desired temperature and hot wells for holding time. These processes combine high agitation with fairly rapid heating rates. Their chief features are convenience and economy, but for best results they are occasionally supplemented with milk treated by the "superheating process." Holding time in the hot well and temperature of holding are varied with the season.

Steam - Milk Mixers

An interesting process, which is used occasionally, employs the so-called "torpedo." This is a small chamber in which milk and steam are mixed, usually under pressure. It involves a very high rate of heating and the temperature is often above 212°F. It produces a milk with high heat stability, provided the milk is fairly stable to begin with. If the milk is of moderate to low in heat stability, no improvement in heat stability is obtained. You will note the similarity of this process to the "superheating process" in that both involve high rates of heating and high agitation; the difference is in the time of holding under high agitation. In steam-milk mixing, part of the milk is heated presumably to a high temperature and the remainder is heated by the mixing which occurs. Analysis indicates also a marked drop in labile sulfur as compared with the "superheating process." Furthermore, evaporated milk made from superheated milk is subject to feathering or coagulation in hot coffee, while the milk from the steam-milk mixer is normal.

I believe you will agree that the hot-well process is more complicated than generally believed and that the variation in process adopted at any time is largely a matter of judgment. It is generally not realized that the process is varied almost daily, usually by a change in the temperature of holding and preheating. The process is governed by the results obtained at the sterilizer.

At this point I should like to add a note of explanation. The hot-well time and temperature are varied so that the use of stabilizers, such as disodium phosphate, can be held to a minimum. However, there is a limit to this time-temperature increase; for example, it is generally found that an increase in holding time from 5 minutes to 10 minutes at 210°F. results in a marked increase in the heat stability of the evaporated milk. However, an increase in time from 10 minutes to 20 minutes produces less marked results and if the time at 210°F. is extended beyond 30 minutes a loss in heat stability usually occurs. If an operator is unfortunate enough to enter the zone of decreasing heat stability he is in real trouble, because none of the legal stabilizers are effective for stabilization. His only solution is to stabilize this lot of milk by mixing with another lot of greater heat stability.

Composition and Heat Stability

Perhaps I can illustrate the relationship between a simple hot-well process and the seasonal composition by referring to data taken many years ago at a Midwestern plant. In this particular case the hot-well holding time was approximately 15 minutes; a single pass preheater was used with an upper heating limit of about 150°F. Therefore, the process is reported in terms of temperature at the preheater and temperature in the hot well. The hot-well process was intended to reduce the stabilizer requirements to a minimum.

In about a week after the milk was sterilized, analyses were made for calcium, total protein and total phosphorus and these data were collected at irregular intervals during a period of 10 months. The data are reported on the basis of 18.10% nonfat solids.

TABLE I

Relation Between Composition and Process

Date	Protein %	Calcium %	Phosphorus %	Hot-Well Process °F. Preheater	Hot Well
10/11	7.07	0.251	0.196	135	195
11/24	6.75	0.255	0.193	155	207
12/8	6.65	0.256	0.187	150	210
2/13	6.35	0.251	0.195	145	204
3/27	6.25	0.249	0.187	145	203
4/22	6.41	0.249	0.194	140	200
5/11	6.79	0.245	0.199	[illegible]	[illegible]
5/25	7.09	0.245	0.209	120	185

You will notice that the condensery operator adjusted the hot-well treatment as the composition changed. There is good correlation between the process and the composition. For example, compare the data of October and February. The calcium and phosphorus contents are the same, but there is a large difference in the protein content. While calcium and phosphorus are a part of the protein molecule, it is evident that a greater concentration of both calcium and phosphorus exists outside the molecule in the February milk. Apparently, the increased temperature treatment in February is an effort to reduce the effective calcium ion and perhaps the calcium phosphate concentration.

It is easy to assume that the principal factor in heat stability is the calcium ion concentration. The evidence from several sources supports this view and it may be correct. However, it is difficult to account for some of the heat stability phenomena on this assumption alone. For example, we have the effect of traces of copper and those hot-well treatments discussed previously which have marked effects on the heat stability. It is also possible to speculate with some success on the ratio of calcium phosphate to protein.

Composition and Viscosity

It is usually not difficult in commercial operation to produce the desired heat stability by variation in the hot-well process and by the addition of stabilizers, but it is difficult to produce consistently the desired viscosity. The generally satisfactory physical properties of milk manufactured in October has been the goal toward which all strive to duplicate at other seasons of the year by variations in either the hot-well process or the sterilization process. One innovation has been the use of "superheated milk" as described previously. However, it is not a popular process, for unless handled carefully, there is danger that the sterilized milk will gel

on storage or feather or coagulate unduly when used in hot coffee. But a very satisfactory viscosity and fat stability can be achieved. Another approach to offset the effects on fat separation of the lower viscosity of milk manufactured, for example, in March is by an increase in the homogenizer pressure, which unfortunately produces a loss in heat stability not usually stabilized by disodium phosphate. So even with the variations made in the hot-well process there are no legitimate methods of which I am aware that can convert a low protein, high calcium milk into a milk equal in physical properties to a high protein, moderately high calcium milk.

Sterilization

The probability of greatly improving the physical properties of sterilized milk by variations in the conventional sterilization process is not very high. In the first place, a certain time and temperature are necessary for sterility. If the can speed is increased in the continuous sterilizer, the time is decreased, which usually indicates the need for an increase in the temperature of the cooker, because most processing is held near the minimum safe temperature required for sterilization at any given time. There is not much flexibility. For example, the increase in can speed, that is, more cans per minute through the sterilizer, increases the agitation which has an adverse effect on the heat stability. The effect of the decrease in time and increase in temperature varies with the milk composition. For example, we may have two evaporated milks which require 14 minutes at 243°F. to arrive at the grain point. However, if these milks are processed for 10 minutes at 247°F., approximately comparable in sterilizing value to the previous process, we may find one milk severely grained, while the other milk is not grained. Therefore, the effort to improve the physical properties of sterilized milk by manipulation of the time-temperature relationship has not been particularly successful.

Defects in Manufacture

So far, I have discussed the general methods of operation and some of the more common problems. I should now like to discuss some of the specific problems which develop in the sterilization process and the age defects.

I mentioned earlier the problem of "burn-on" and "smear-on." To most of you these may appear to be trivial, but these problems are a constant source of annoyance to the technologists, because the cause of the defects is obscure. It should be realized that the function of the sterilizer preheater is to reduce or eliminate the "burn-on." If the "burn-on" can be eliminated by other means, we do not need the preheater.

There is always a certain amount of foam present when the cans leave the filler. The milk also contains more or less dissolved air. But why foam appears to coagulate and adhere to the can walls in some cases and then build up in amount in the cooker is unknown, at least to me. We do know that some types of enamel-lined cans are more subject to this defect than plain tinned cans, so apparently the surface of the tin plate is a factor. Perhaps a trace of a silicone, if allowable, would be desirable. It is also known that an increase in vacuum in the can increases the "burn-on." Therefore, the sterilizer preheater is used prior to the cooker, not only to allow time for the foam to dissolve or disperse, but also to reduce the

difference in temperature between the milk and the cooker. The greater this difference, the greater will be the evaporation from the foam surface, the milk acting as the condenser. And if this difference is greater than 25°F. most milks will show some "burn-on." Even an extremely short exposure to a high temperature differential is sufficient to initiate this defect.

It would appear that "burn-on" is related to the heat stability of the milk, but "burn-on" is frequently most severe in May or June when the heat stability is usually high. Thus it appears to be a question of composition, but so far as I know, no one has ever analyzed the "burn-on." Is it a cross section of the milk proteins, or is it primarily a coagulation of the whey proteins or some fraction thereof? I suspect the whey proteins are a factor, but it would be helpful to know.

Sometimes the "burn-on" does not adhere strongly to the can walls but becomes detached and then it may be mistaken for grain from over-sterilization or lack of heat stability. Therefore, the operator must be able to distinguish between grain from lack of heat stability and grain originating in foam. This is not always easy to do.

"Smear-on" does not occur with milk of good heat stability. It is almost always associated with milks of naturally low heat stability, that is, milk low in protein in relation to the calcium phosphate or briefly, winter milk. Therefore, a low temperature - long time sterilization process, for example, a cooker time of 14 minutes at 243°F., will usually not produce this defect. It is a heat stability problem in that milks exhibiting this defect have a steep coagulation curve, that is, they are exceptionally sensitive to high temperature sterilization. I believe you can realize the difficulty in attempting high temperature in-can sterilization of milks with this property. I might add in this connection that a trace of copper in the raw milk prior to the hot-well process changes the slope of the coagulation curve and in most cases permits high temperature in-can sterilization. The addition of copper is illegal and also undesirable for flavor reasons, but it does furnish a clue as to the basic problem involved.

Steam - Air Preheater

The "burn-on" problem can be reduced, but not necessarily solved, by the use of a steam - air preheater. While time does not permit me to go into the details of this improvement over the conventional preheater, it may be sufficient to outline its function.

As you well know, the temperature of the water at the entrance portal of the conventional preheater is roughly 100-120°F. and the temperature at the exit portal is approximately 212°F. This allows the center-can temperature of the milk to rise to approximately 208-210°F. before the can leaves the preheater. In the case of the steam - air preheater, the heating mixture is steam and air, and the temperature at the entrance portal may be, for example, 220°F. and at the exit portal 240°F. The steam-air mixture reduces the heating rate and this rate can be changed by varying the percent of air. The effect of this innovation is to allow for a higher center-can temperature at the exit portal; in the case cited at least 230°F. Usually the "burn-on" in the cooker is reduced markedly and if not, it may be necessary to increase the air percentage. Usually it will be found that

a temperature differential between the milk and the cooker should be less than 25°F. or "burn-on" will occur. Therefore, it is possible with this preheater to use a cooker temperature 20°F. or more higher with no greater danger of "burn-on" than usual and less if the temperature differential is reduced. I should add that "burn-on" generally originates in the preheater, but it is built up during the cooker process. So even a slight exposure to pure steam in the preheater should be avoided.

While "burn-on" is a problem generally originating in the difference in temperature of the cold milk and the cooker, skins are a problem in the cooler, owing to the difference in temperature of the hot milk and the cooling water. In the first case evaporation of water from the foam occurs which causes the initial coagulation; in the latter instance evaporation occurs at the surface of the milk in the headspace owing to condensation of steam by the cooling water. The cases are similar, but reversed and the solution is similar. One solution employs a small steam jet in the cooling water at the point the cans enter the water. This allows for some agitation and a local temperature rise. Usually a temperature of 140°F. locally is sufficient to prevent skin formation. In other words, the temperature differential is reduced at a so-called "hot spot." Agitation can be introduced and is effective.

Storage Problems

The problems of the manufacturer are not over until the milk is consumed. The average age of milk is near 3 months before it is purchased by the consumer. However, the temperature of storage is a factor; for example, storage at 85°F. produces an aging effect double that at 70°F. So the manufacturer frequently places milk in moderately cold storage whenever the market is slow.

There is probably some difference of opinion about the relative importance of storage defects. They are usually listed as fat separation, mineral deposits or lime grain, sedimentation and gelation, browning and flavor deterioration. For many the flavor deterioration is most important and in my opinion it gains in importance as the effort is made to produce milk light in color and mild in flavor. With the long time-low temperature processes commonly used, slight flavor changes are not highly important, but with high temperature-short time processes, flavor changes become highly important. This is a difficult situation, but recently some progress has been made on the age effect, that is, the objectionable flavor normally associated with aged milk has been reduced to some extent, at least in one commercial product now being market tested.

For standard evaporated milk, fat separation probably receives the most attention. It is well known that a small globule size and a stable viscosity appear to be most important. However, a small globule size does not necessarily insure freedom from fat separation. Clumping of fat, whether from the homogenization process or over-sterilization frequently results in fat separation. These defects are not always easy to detect at the time of manufacture.

The precipitation of calcium citrate - sometimes called lime grain - is seasonal in that it occurs chiefly in the late winter months in the Middle West or in regions in which Holstein cows predominate. In the South,

however, mineral deposits occur throughout the year. The cows are chiefly Jersey.

No entirely satisfactory solution for this problem has been found, at least to my knowledge. Disodium phosphate is effective to a degree, but the amount that can be added is limited not only by law but by the limitations of heat stability and viscosity.

Conclusion

I believe I have covered, briefly, a few of the well known methods and problems of in-can sterilization of concentrated or evaporated milk. In general, it has been a discussion of time, temperature and agitation and its effect on the heat stability of milk. What I have not pointed out, but I shall do so now, is that the work on in-can sterilization, if projected by calculation, and speculative at best, into the 270-290°F. temperature zone indicates that most milks should coagulate at these temperatures with the times normally used in bulk sterilization, followed by aseptic filling. Now, we know there is usually no evidence of coagulation as judged by our usual standards; in fact, some of these milks appear very heat-stable after sterilization. Are they in fact coagulated but in an extremely fine state or is an extremely high agitation or turbulence during sterilization a factor contributing to the apparent heat stability? Briefly, I believe we have a fairly good idea of the effect of time, temperature and low degrees of agitation on the heat stability of milk, but if we are to proceed into high temperature sterilization, then it becomes necessary to know more about the effect of high turbulence on the heat stability. I hope to hear this discussed during this meeting. I thank you.

Discussion

H. Klaessig, The Borden Co.: Are the terms feathering and coagulation similar?

Victor Nelson: Yes, I use the two terms interchangeably.

F. J. Doan, Pennsylvania State Agricultural Experiment Station: Why are mineral deposits important since so many consumers punch holes in the evaporated milk cans and never see them?

Victor Nelson: They are important largely in the case of infant feeding. The deposits become detached and cause clogging in the nipples.

SOME EFFECTS OF HEAT ON THE CONSTITUENTS OF MILK

by
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The widespread use of heat treatments in the manufacture of concentrated milk products makes a consideration of its effects of paramount importance. Many of the problems resulting from the effects of heating have been known for a long time, and some of them have been solved in a practical and empirical manner. Knowledge of the underlying mechanisms has been slow to accumulate, however, and many phenomena still remain unexplained.

A considerable portion of the interest in the effects of heat centers around the milk proteins. Both the casein and the whey proteins are involved and in some respects their responses to heat treatment are interrelated.

The pervading theme of this paper is the effect of heat on the stability of the caseinate particles. Heat denaturation of the serum proteins will be discussed in relation to this general topic.

Nature of the Caseinate Particles

The caseinate particles consist of the protein casein, calcium, magnesium, phosphate and citrate. Their composition, on a dry basis, is approximately as follows: casein, 94%; calcium, 3%; magnesium, 0.1%; inorganic phosphate (as $PO_4^{\equiv}$), 3%; and citrate, 0.4%. In this paper they will be referred to usually as containing casein, calcium, and phosphate.

Casein.--The term "casein" is used in this paper to designate the acid-precipitable, rennet-coagulable fraction of the milk proteins which amounts to 2.5 to 3.0% of the milk. Casein is now known to be a mixture of components which are co-precipitated by acid or rennet. It has been separated into three rather well defined fractions which have been designated alpha, beta, and gamma, which comprise respectively about 75%, 22%, and 3% of the entire casein. These fractions differ in phosphorus content, amino acid composition, electrophoretic mobility, and isoelectric point. The principal work in isolation and characterization of these fractions has been conducted at the Eastern Utilization Research Branch of the U. S. Department of Agriculture. The most characteristic feature of the composition of casein is the fact that it contains about 0.85% phosphorus as orthophosphate esterified with aliphatic hydroxyl groups of the amino acids serine and threonine. Actually, alpha-casein contains about 1% phosphorus, beta-casein 0.6% and gamma-casein none.

Constitution and Size of Particles.--The fine structure of the caseinate particles is far from being completely elucidated. Several questions that have intrigued and puzzled investigators in the field are whether (1) the alpha, beta, and gamma components are present in the same or separate particles; (2) the inorganic phosphate is present in the complex in the divalent or the trivalent state; and (3) the casein, calcium, and inorganic phosphate are associated by physical or chemical forces.

The alpha, beta, and gamma components cannot be separated by fractional centrifugation of skim milk, and thus it seems that each particle either contains all three components or that, if they are present in separate particles, each component has the same distribution of particle sizes. The fact that the pH is raised when the particles are disrupted by removal of the calcium with neutral oxalate indicates that the inorganic phosphate is present in the trivalent state. Present evidence indicates that the casein, calcium, and inorganic phosphate are associated through ionic forces, or, in other words, through salt linkages. There is no good evidence for the existence of a separate colloid-calcium phosphate, which is protected by calcium caseinate. Rather the particles appear to consist of some sort of double salt.

The techniques of centrifugation and electron microscopy have been employed in determining the size distribution of the caseinate particles. Both techniques show that they vary greatly in size from 30 to 300 mμ in diameter. Ultracentrifugal work by Ford indicated a dominant particle size of 168 mμ, whereas the electron microscope measurements of Nitschmann and of Hostettler and Imhof showed most of the particles in the range of 50-100 mμ. Present data do not permit an unequivocal decision as to whether or not the size variation is continuous or discontinuous.

Equilibrium between Particles and Environment.--It is important to remember that the caseinate particles are in equilibrium with the ions and salt complexes present in solution in milk. Indeed, these particles may be said to be an important component of the salt equilibrium of the milk. Thus calcium and magnesium occur in milk partly in the form of free ions, partly in the form of undissociated, dissolved complexes with phosphate, citrate, and carbonate, and partly in the colloidal caseinate particles. The distribution of calcium and magnesium among these several forms is markedly influenced by differences in temperature and in pH.

The particles are very sensitive to changes in the ionic environment; they readily aggregate with increase in concentration of calcium or magnesium ions and break up with decrease in concentration of these ions. They are poised in a labile or precarious equilibrium in the milk. Conditions which upset this equilibrium will tend to destabilize the particles. It must be remembered, however, that the environment of the caseinate particles also includes lactose, whey proteins, and fat globules. Obviously, interaction of any of these materials with casein or with components of the ionic environment may alter the stability of the caseinate particles. In concentrated and dry milk products, the aim is usually to avoid or at least to limit the destabilization of the caseinate as much as possible. It is proposed to discuss the influence of procedures employed in concentrating and drying on the stability of caseinate particles and the relation of the stabilization to the utility of various concentrated and dry milk products.

The Phenomenon of Destabilization

In this paper destabilization of the caseinate particles will be taken to mean loss of original degree of dispersion. This may be of a degree detectable only by electron microscopy or centrifugation, or it may consist of flocculation in the form of loose curds or "grains," or of gelation. In any event it is considered to represent an aggregation or agglomeration of

the particles. If the process occurs while the product is in a quiescent state, a network may be formed encompassing the entire volume of the product (gel). Upon continued standing this network may contract, expelling some of the occluded milk serum (syneresis).

In general, a straight-line relationship exists between the temperature and the log of the time necessary to coagulate milk. However, work by Cole and Tarassuk indicates that significant deviations from a linear relation sometimes occur. The slope of the plot varies somewhat from milk to milk, so that there is no single universal relationship applicable to all milks.

At present there is much interest in the use of high temperature and short time for sterilizing various concentrated milk products. Such treatments take advantage of the fact that the slope of the time-temperature curve for sterilization is steeper than that for heat coagulation or browning. Thus high temperature-short time treatments will give sterilization without destabilization or browning. However, products prepared in this way exhibit undesirable thickening and fat separation in storage. It remains to be seen if conditions can be found which will cause the development of adequate initial viscosity and age stability without at the same time causing excessive browning.

Fundamental Factors Influencing Stability

In general there are four fundamental factors that influence the stability of caseinate particles. These are: pH or acidity, salts and ions, enzymes, and heat treatment.

Effect of pH.--Caseinate particles are very sensitive to changes in pH. As mentioned above, casein is defined as that protein which is precipitated from milk by adjustment to the isoelectric point at pH 4.6, but even at pH's other than the isoelectric point the caseinate particles are very sensitive to changes in pH. The sensitivity to coagulation by cations or by heat treatment is increased enormously if the pH is decreased a few tenths of a unit below the normal value. Conversely, raising the pH above the normal value decreases the susceptibility to coagulation by cations or heat treatment.

Effect of Salts and Ions.--The caseinate particles can be salted out of dispersion with high concentrations of salts, e.g., by saturating milk with sodium chloride. Of more interest in the present connection, however, is the effect of small quantities of polyvalent cations. As previously mentioned, casein exhibits a strong tendency to aggregate in the presence of these cations and very small concentrations are sufficient to bring about a coagulation or gelling of the particles in milk. As a matter of fact, variations in behavior of natural milk in stability to coagulation have been attributed to variations in the concentration of ionized calcium. Until recently it has not been possible to study the relation between calcium ion concentration and stability because of lack of methods for determining calcium ion concentration unequivocally. However, methods have recently been published which give an indication that it will be possible to make such studies in the near future.

Effect of Enzymes.--Proteolytic enzymes in general tend to render casein more susceptible to coagulation by cations with very little actual

proteolysis. It appears that the opening up of a few crucial linkages by proteolytic action has a very pronounced effect on the stability of the protein to coagulation by cations. Of course, in the dairy field interest in the coagulation by rennin is of tremendous importance. This enzyme is proteolytic but exhibits a very weak proteolysis at the pH of milk. Actually it tremendously increases the susceptibility to coagulation with cations with degrees of proteolysis which are scarcely detectable. It apparently catalyzes an irreversible change in some particularly crucial linkages in the protein.

Effects of Concentrating and Drying on Stability of the Caseinate Particles

It is well known, of course, that concentration of milk renders the caseinate more sensitive to destabilization. The question to be considered at this point is how concentration produces this result.

One important effect of concentration is the shift that it produces in the salt equilibria. Upon concentration of milk calcium, phosphate and citrate are transferred from the dissolved to the colloidal state and the pH drops. The combined effects of lower pH, more colloidal salts, and higher concentration of particles per unit volume result in a lower stability. Thus, for example, less heat is necessary to destabilize a concentrated product than the original unconcentrated starting material. In general, the heat stability decreases linearly as the concentration is raised.

Another effect of concentration is to alter the rate of reactions that occur during heating. The shift in pH and the increased concentration of reactants may both be involved here.

Effect of Heat Treatment.--Heat treatment is of tremendous importance in relation to the stability of the caseinate in concentrated and dry milks. The effects of heat on the particles may be both direct and indirect.

1. Effect on Casein Itself. The only pertinent known direct effect of heat on the protein itself is degradation with release of esterified phosphate and hydrolysis of peptide linkages. Thus Howat and Wright demonstrated considerable degradation and dephosphorization when sodium or calcium caseinate sols were heated at 120°C. for times up to 5 hours. A 3.5% calcium caseinate sol coagulated after being heated for 2 hours and losing about 57% of its phosphorus. No satisfactory data are available showing the extent of dephosphorization and degradation occurring in milk itself during heating.

The term "denaturation" is often employed in discussing the phenomenon of the destabilization of the caseinate system. This term, however, is usually reserved (at least by protein chemists) for non-hydrolytic rearrangements in configuration of a protein. Such changes have never been demonstrated to occur in casein and hence the use of the term is inappropriate. Thus in this paper the term "destabilization" will be used.

2. Effect on Calcium and Phosphate. It has been observed frequently that the concentrations of dissolved calcium and phosphate in milk are decreased by heat treatment in the range 60-100°C. Considerable data are available

on this point but there is lack of agreement as to the extent of the change. Variations that have been observed may be explained by the following facts: (1) The transfer is slowly reversed on holding the milk after heating. Thus, the results will be influenced by time elapsed after heating before a sample of ultrafiltrate or dialysate is prepared for analysis. (2) Methods of separating the phases for analysis have differed among workers. (3) Possibly variations in the level of carbon dioxide influence the effect of heat treatment on the dissolved calcium and phosphate. In spite of the observed discrepancies, the fact remains that calcium and phosphate are transferred reversibly from the dissolved to the colloidal state by heat treatment in the range 60-100°C. Since the concentration of calcium and phosphate in the dissolved state decreases upon heating and they are not precipitated, it is presumed that they become connected in some way, perhaps adsorbed to the colloidal caseinate particles. Furthermore, the original fine structure of the particles may be altered; the original double salt, calcium caseinate-calcium phosphate, may be changed to a system comprised of tricalcium phosphate adsorbed on calcium caseinate. There are no data on this point. However, it is important to emphasize that the mere fact that the level of dissolved calcium and phosphate tends after heating to revert to the original value does not necessarily imply that the original conditions are regained throughout the system. The nature (fine structure) of the colloidal caseinate particles may have been changed.

The insolubilization of Ca and phosphate results in depressing the concentration of Ca ions in the milk. Even in unheated milk, only a small portion (about 1/10) of the calcium is present in the ionized form. The remainder is tied up with the casein and also in dissolved complexes with phosphate and citrate. Heat treatment in the range 60-100°C. decreased this still further. Also concentration of the milk decreases the calcium ion concentration.

3. Loss of CO_2. Milk as secreted by the cow contains about 20 mg. of carbon dioxide per 100 ml. (or about 10% by volume). This gas is rapidly lost from milk because of the low content in the air. Ordinary commercial milk may contain about half of the original carbon dioxide. The loss of carbon dioxide from milk is accelerated by heating and agitation. It would be anticipated that the removal of carbon dioxide would affect the balance in the rest of the system. This can be determined, uncomplicated by other effects of heat treatment, by removing carbon dioxide by vacuum treatment without heating. Actually the entire carbonate system can be removed from milk in this way with a resulting increase in pH. It would be expected that the increase in pH would be reflected in a decrease in dissolved calcium and phosphate and probably also in calcium ion activity, but this has never been demonstrated.

4. Effect on Acidity. The removal of carbon dioxide causes an increase in pH and a decrease in titratable acidity, as already pointed out. This effect is counteracted upon heat treatment by hydrogen ions liberated by insolubilization of calcium and phosphate. The effect is as though the following reaction occurred:

$$3Ca^{++} + 2HPO_4 = \longrightarrow Ca_3(PO_4)_2 \downarrow \pm 2H^+$$

In some cases, these two opposing factors so nearly counterbalance one another that there is no net change in pH. High-temperature heat treatment results in an increase in acidity as a result of the cleavage of ester P from the casein and also in production of acids such as lactic and formic by degradation of lactose. The rate of this latter reaction is slow up to 90°C. but increases rapidly as the temperature is raised. At 100°C. and higher the acid produced in this way overshadows any effects of loss of carbon dioxide or precipitation of calcium phosphate. This increase in acidity, of course, brings calcium and phosphate back into solution, increases the Ca^{++} ion concentration, and decreases the stability of the caseinate particles.

5. Effect on Serum Proteins. The serum proteins of milk are denatured by heat treatments in the range 60-100°C., one principal manifestation of heat denaturation being insolubility at pH 4.7. Thus in heated milk these proteins tend to precipitate with the casein when the latter is precipitated by acidification. It is important to note that the whey proteins do not precipitate from heated milk so long as the pH is maintained at the original level at 6.6. It is sometimes considered that possibly the denatured serum proteins do not precipitate from heated milk at pH 6.6 because they interact with and become attached to caseinate particles during heating. This whole question of a possible interaction of certain serum proteins with one or more of the components of the casein mixture is being studied in several laboratories. It is not yet clear whether the extensive interaction does occur and, if it does, if it has any bearing on the stability of the caseinate particles. This is an area that is being studied and deserves further study.

Volatile sulfides released from the serum proteins when they are heated may also be involved in destabilization of the caseinate particles. Nelson has shown that hydrogen sulfide added before heat treatment is a very potent destabilizer.

6. Sugar-Protein Interaction. The "browning reaction," which occurs when proteins or reducing sugars are heated together in solution at temperatures of 100°C. and and above, is all too well known in the evaporated milk industry. Among other results of the browning reaction is insolubilization of the protein. It is not known to what extent, if any, this reaction is involved in the heat destabilization of the caseinate of milk, but it definitely needs to be considered.

7. Stabilization by Forewarming. It is well known that a forewarming treatment before evaporation greatly increases the stability of the evaporated product to coagulation during sterilization. The mechanism of this effect is not known at present. Suggestions have been made that forewarming exerts its influence through shifts in salt equilibria or through denaturation of the serum proteins. To date, optimum forewarming treatments have been developed empirically without regard to the mechanisms involved. Early work indicated that a maximum stability was attained by forewarming at 95°C. for 10 minutes. More recent work has demonstrated the superiority of high-temperature short-time treatments for this purpose. Such treatments even permit the production of milk of 32-37% total solids that is stable to sterilization.

HIGH-TEMPERATURE SHORT-TIME STERILIZATION OF WHOLE MILK AND OF CONCENTRATED MILK

by
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Sterile whole milk is not a new product. It has been prominent in England and continental Europe for more than 50 years, where it is sterilized in the bottle at 225 to 230°* for about 30 minutes. These high temperatures and long exposures cause a strongly cooked flavor which, however, is not objected to by the consumers. Sterile milk has served about the same needs in foreign countries as certified milk did in this country before pasteurization was universally adopted.

Recently equipment has been developed for heating milk in one to three seconds to about 300° and cooling it rapidly to about 40° (1) (2) (3). The heating and cooling cycle requires from 5 to 12 seconds, depending on the type of equipment. The whole milk and concentrated milk are canned aseptically and have superior flavor and color to the same milks sterilized in the can.

General Methods

The Mallory heater is being used in our research. Milk preheated to 140° can be heated in this unit at about 100°/second with a steam pressure of 100 to 102 psi. Steam pressures of 80 to 83 psi were used when milk was sterilized at about 300°. The milk is collected from the heater in sterile 10-gallon stainless steel cans which are equipped with sanitary fittings. The milk is bottled under virtually aseptic conditions in a small chamber made of lucite, which can be practically sterilized with chlorine or quaternary ammonium aerosols. These vapors can be removed with nitrogen or carbon dioxide. The asepsis of this procedure was evaluated by bottling nutrient broth which had been sterilized in the 10-gallon can. Bottling this medium has proved useful in evaluating the different phases of the sterilization procedure as it is necessary then only to observe the bottles for turbidity at the different storage temperatures, thus eliminating much routine bacteriological work. In sterilizing milk every surviving organism, regardless of its source, becomes an important statistic. Temperatures of 280.5 to 325° have been used in our work, but we have not been consistently successful in sterilizing milk from different sources at the lower theoretical range of 280.5 to 282°.

Results

Nitrogen Distribution. Comparisons with raw milk revealed an apparent increase of casein nitrogen of 40 to 50 mg/100 ml. in milk sterilized at 300° and the noncasein nitrogen showed an apparent decrease of about 35 mg/100 ml. During storage at 70° there was a gradual reversion of casein and noncasein nitrogen toward values found in the raw milk. Reversion

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* All temperatures in this paper are °F.

occurred fastest at 100° and slowest at 40° where the values in the raw milk were not achieved during four months. Milk sterilized at 280.5° showed reversion changes, and there was also an increase in nonprotein nitrogen, indicating enzyme activity.

Phosphatase. The enzyme phosphatase in milk sterilized at 300° and held one week released 0.5 gamma of phenol per ml. of milk at 40°, 1.6 gamma at 70°, and 1.3 gamma at 100°. At 4 months storage the values were 2.9 gamma at 40°, 14 gamma at 70°, and 3.7 gamma at 100°. Milk sterilized at 280.5° and held 7 days released 12.8 gamma at 70° and 10.1 gamma at 100°. Milk concentrated 3 to 1 and sterilized at 305° released 10 and 12 gamma of phenol per ml. of milk after 7 days at 70° and 100°, respectively. The enzyme is reactivated, because tests made without the substrate disodium phenylphosphate have ruled out interfering compounds as being responsible for the positive phosphatase tests of sterile milk. Furthermore, heating sterile milk containing reactivated phosphatase at 143° for 10 minutes resulted in a negative test, indicating the enzyme was again heat labile.

Fatty Materials. The stability of the fatty materials in the milks sterilized at 280.5 and 300° was followed during storage at 40, 70 and 100°, using the thiobarbituric acid and peroxide tests. The values were always highest in the milks stored at 100° and lowest at 40°. There does not seem to be a close correlation between these tests and flavor deterioration.

Flavor Effects. The flavor score of milk immediately after sterilization at about 300° was 39. After one week it was 39.5, 37, and 36, at 40°, 70°, and 100°, respectively. In general, the flavors changed from slightly cooked to stale at 70° and stale to oxidized at 100°. The milk concentrated 2 to 1 and 3 to 1 and then reconstituted to whole milk showed about the same flavor scores.

Effects on Vitamins. Ascorbic acid decreased about 15 percent in the milk sterilized at 300°. After one week at 40° it had decreased about 40 percent, at 70° about 60 percent, and at 100° about 80 percent. After two months at 40°, the milk had lost about 85 percent of its ascorbic acid and it was practically gone at 70° and 100° storage. Ascorbic acid disappeared much sooner in the concentrated milks.

There was no significant change in the carotene and Vitamin A contents of whole milks sterilized at 280.5 and 300° and stored three months at 40, 70, and 100°. Both were lowered about 10 percent during sterilization in the milk concentrated 3 to 1, but there were no important changes during three months at the three temperatures.

Thiamine decreased by about 10 percent during sterilization, but it showed an apparent slight increase at 40 and 70° storage. This increase was probably due to interfering or fluorescent compounds formed during storage.

Physical Stability. Sterilizing whole milk at nearly 325° resulted in a slow sedimentation of milk solids, which formed a gel structure at the bottom of the container. The sediment was analyzed and contained relatively large amounts of fat. The fat concentration in the sediment was greatest in the milk stored at 40° and lowest at 100°.

The sterilemilks had higher viscosities than their raw milks, and the viscosity increased as the temperature was raised to about 325°, which was the highest temperature used. However, the higher viscosity did not result in greater physical stability, as sedimentation of milk solids was greatest in the milks sterilized at the higher temperatures and it was also greatest at the higher storage temperatures. Sedimentation is undoubtedly related to the viscosity of the water phase. The viscosity of water is about 2.2 times greater at 40° than at 100°. At 40° water has four hydrogen bonds per molecule and at 100° the average number is two. As the temperature increases, the number of hydrogen bonds decreases, and the energy of viscous forces also decreases. This network of hydrogen bonds accounts for the viscosity of water and some of its other properties, and undoubtedly these same forces are important in milk. The effect of temperature on the hydration of the proteins is also important.

The temperature of preheating and of sterilizing concentrated milk (2 to 1 and 3 to 1) affects sedimentation of the milk solids and flotation of the fat. Preheating at 230° yields a more stable product than it does at 180°, though there is some sedimentation during storage at 70 and 100°. Migration of solids in the container during storage is being determined by quickly freezing the cans in a dry ice-acetone mixture and then cutting the contents horizontally in sections which are analyzed for fat and total solids. It is planned to make analyses also of other constituents.

After about 30 days storage at 100°, gel formation was observed in the milk concentrated 3 to 1 and after two months it was observed in the milk held at 70°; while the milk stored at 40° had increased in viscosity, there was no gelation after four months.

General Discussion. It is believed that studies of the effects of heat on simplified systems of the whey proteins and of casein and the effects of calcium, potassium, and phosphate ions on the stability of these systems will yield useful information in finding the optimum preheating and sterilizing temperatures. In a somewhat analogous phenomenon, biologists have found that the cell wall consists of protein and phospholipid micelles containing more calcium than potassium. Within the cell there is less calcium and more potassium, which tends to disperse proteins. And calcium ions favor gelation of freshly cut surfaces of protoplasm while an excess of potassium ions hinders it. The heat-induced gelation of sterilized milk may be due to an unbalanced protein-cation system. Considerable research has been reported for the effects of heat on calcium in milk, but potassium has been neglected, even though it is present in milk in a higher molar concentration than any of the other mineral cations.

It can be predicted that heat sterilization of milk will be used for at least another decade and probably longer, because sterilization with ionizing radiations has proved impractical due to effects on flavor and food value and prohibitive costs. It has been shown in pilot operations that high-temperature short-time sterilization of whole milk and concentrated milk and aseptic bottling results in acceptable palatability and food value. Furthermore, palatability can be maintained for 4 to 6 months at 40° storage and undoubtedly longer at 32°. Storage at close to 32° is the best practical means of maintaining palatable keeping

quality and physical stability of these sterile liquid milk products. At lower temperatures of -15 to -20° they become destabilized with separation of solids when warmed to about 40°.

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Discussion

Question 1. Are the whey proteins important in emulsification despite denaturation of the proteins?

Yes, it appears that the whey proteins affect the stability of milk. Of the temperatures of preheating used in our experiments, 180° is superior to 140° and 230° is superior to 180°. However, the effect of heat on the interaction of the different protein systems in milk also may be important.

Question 2. What system of scoring was used by the taste panel?

The American Dairy Science system of scoring was used. A perfect score is 45, and a score of 40-45 is not criticized, although scores over 40 are seldom given.

Question 3. How long were the milks held at 300°?

In some experiments the holding time was 2.5 to 3 seconds, and in some it was 1 to 1.5 seconds, and at higher temperatures it was less than 0.1 second.

Question 4. When were the storage samples checked for sterility?

In general, they were plated by the standard plate count method at weekly intervals for the first month and at monthly intervals for the next five months. Storage at 100° has proved to be the most practical criterion for sterility.

Question 5. What strength chlorine was used in sterilizing the bottling chamber?

We used 15-20 ml. of solution containing about 500 ppm of chlorine. The vapor is flushed out with nitrogen gas.

Question 6. What kind of stale flavors were observed in whole milk--were they the same as in the concentrated milk?

In general, the flavors were what might ambiguously be called stale in both the whole and concentrated milk.

Question 7. Did you test for catalase?

No. The literature indicates that catalase may be completely inactivated at sterilization temperatures. However, a proteolyte enzyme may not be completely inactivated.

Question 8. Is there reversion of the proteins after sterilization at 282 °F.?

Yes, there is.

Question 9. Have you made observations on destruction of lipase?

Yes. It is inactivated during sterilization.

Question 10. Was the oxidized flavor which developed at 100° observed on whole milk or 3-to-1 concentrate?

It was found in whole milk, but not in the concentrate.

Question 11. Don't you believe stale when used to describe flavor is so vague and meaningless as to connote nothing?

Specifically, you are right. Dr. R. M. Whitney, in our department, is studying the chemical compounds responsible for the so-called stale flavor.

Question 12. Is there a decrease in the cooked flavor in milk held at low temperatures?

Yes, but a heated flavor is always present.

Question 13. Did you observe any graininess?

Yes, when the milks were sterilized at 315°-325°.

Question 14. If you objectively consider the sterilization of milk for beverage purposes, there are certain flavor defects. Are you optimistic regarding development of concentrated sterile milk for beverage purposes, especially in regard to flavor deterioration; can you see any hope?

Yes, using high-temperature short-time sterilization and aseptic canning, I believe it is possible to produce a milk with acceptable palatability, provided it is stored at low temperatures.

Question 15. In your home, do you drink this milk or fresh milk?

Sterile milk has been used in our home and has not been recognized as being different from regular pasteurized milk. Other limited trials have yielded similar results. However, the majority of students in our market milk classes have preferred regular pasteurized milk over sterile milk.

DEVELOPMENT OF MARKET MILK CONCENTRATES IN IOWA

by
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(Summary)

The rural marketing of fresh concentrated milk on a commercial scale was initiated by the Dairy Industry Department at Iowa State College in July, 1951. Five delivery routes were established in the rural areas around the College. The concentrate was sold to a vendor who delivered it to rural customers on a one-delivery-per-week basis. Additional dairy products handled included ice cream, butter, and cheese. Soon after the process was perfected and put into operation, Prairie Farms Creamery in Central Illinois (Henry County) added the new product to existing county cream pick-up routes and ice cream delivery routes.

The Present Processing Method: This is based on the results of work on fresh concentrated milk at Iowa State College which may be summarized as follows:

1. High quality milk must be used to prepare this product.

2. A pre-heating or pasteurizing treatment is necessary prior to condensing.

3. Experience with the single stage homogenizer indicates that the product must be homogenized both before and after condensing to prevent a cream layer formation after storage for 7 to 10 days. However, one homogenization might suffice when other types of homogenizers are used.

4. An acceptable product can be produced by condensing at the usual vacuum pan temperatures of 125° to 135° F. However, condensing at these temperatures will produce varying degrees of a flavor which has been called "harsh cooked" and "stale." This flavor can be changed to a pleasing mellow-cooked, rich flavor by pasteurizing at 180°F. for 16 seconds before and after concentration.

5. Most people agree that the reconstituted product has a fresh milk flavor and is relatively free from volatile feed and grass flavors.

6. Experience has shown that any major deviation in the processing procedure will be reflected in the flavor score of the finished product.

7. The relatively good keeping quality of the product is attributable to pasteurization at high temperatures, double pasteurization and low holding temperatures. The concentration of milk solids is not sufficient to inhibit bacterial growth and the vacuum treatment is without demonstrable effect on the bacterial population during storage.

The following procedure is the present recommended method:

1. Clarify and standardize Grade A milk to 3.5 percent butterfat.

2. Pasteurize at 180°F. for 16 seconds.

3. Homogenize the milk at 2500 pounds pressure and cool to 125-130°F.

4. Condense to slightly over 3:1 concentration in a stainless steel vacuum pan.

5. Pasteurize the concentrate at 180°F. for 20-25 seconds and cool to 40°F.

6. Add pasteurized water to reduce the concentrate to exactly 10.5 percent butterfat.

Keeping Quality: Samples were stored at 35°, 40° and 50°F. for periods up to 30 days. A few samples were held at 70°F., but both the concentrate and the reconstituted product became unusable so quickly that holding at this temperature was discontinued.

Most of the samples stored at 35°F. remained satisfactory in both flavor and bacterial count over a 30-day period.

With the sample held at 40°F. the total count usually increased slowly for about the first two weeks and the concentrate became unsatisfactory from both organoleptic and bacteriological standpoints some time between the fifteenth and the twentieth days of holding. These results would indicate good keeping quality under home storage conditions.

Storage at 50°F. decreased the keeping quality of the product very markedly. The usual sample remained low in count for two days at this temperature, but considerable growth was evident by four days and the counts became very high, and objectionable flavors developed soon after four days at 50°F.

Costs of Processing Fresh Concentrated Milk: Costs of production consist of fixed and variable costs. Fixed costs are those which do not change as output changes. For example, if a man had $10,000 invested in equipment and decided to run his plant 24 hours a day instead of 10 hours a day, it might be assumed the new schedule would not require additional processing equipment. Therefore, equipment costs would be fixed and would not increase with the increase in output resulting from longer hours of production.

The added costs of increasing his schedule to 24 hours would be called variable costs. These costs include expenses for more hired help, more raw materials, money spent for more milk containers and such costs that do vary with the rate of output.

In attempting to estimate the costs of processing fresh concentrated milk, four different cases were considered:

Case 1 - A complete processing plant where only fresh concentrated milk is produced.

Case 2 - Adding the necessary equipment required to process fresh concentrated milk to an existing Grade A processing plant.

Case 3 - Adding the necessary equipment to process fresh concentrated milk to an existing manufacturing plant.

Case 4 - Processing fresh concentrated milk with all the required facilities available.

In each of these cases, costs were calculated at nine different levels of output. The following figures are selected from these calculations and show costs at only the two extreme levels considered, namely, 750 and 15,000 quarts of fresh concentrated milk per week. Seven hundred and fifty quarts of concentrate represents one sales route where the product is delivered daily, five days a week.

Costs

	Sales Per Week (Quarts)	Fixed Cost Per Quart of Concentrate	Variable Cost Per Quart of Concentrate	Average Total Cost Per Quart of Concentrate
Case 1	750	$0.6393	$0.1930	$0.8322
	15,000	0.0320	0.0937	0.1258
Case 2	750	0.0579	0.1930	0.2508
	15,000	0.0029	0.0938	0.0967
Case 3	750	0.3161	0.1828	0.4989
	15,000	0.0158	0.0876	0.1034

In Case 4, for a plant with all the necessary facilities available, processing costs for producing fresh concentrated milk are:

Case 4 -

Nature of Cost	Average Cost Per Quart At Any Output Level	
Marginal evaporating	$0.0036	
Marginal processing and packaging	0.0486	
Plant loss[1]	0.0189	
Total cost of processing		$0.0711
Total cost of processing without considering dumping cost		0.0614
Estimated cost of transportation[2]		0.0210
Cost of processing fresh concentrate assuming custom evaporation and bulk tank rural collection		0.0824

[1]Plant loss calculated at 6 percent of the raw milk dumped. The milk is priced at the Iowa State College Class I price for 1953 - $4.60 cwt.

[2]Cost of transportation of milk for 20 miles within the municipality as estimated by a local trucker.

Delivery costs for a single route were found to be about 10.9 cents per quart of concentrate or about twice the cost of urban delivery.

The processing and delivery costs are such that a plant probably should have Grade A processing facilities available in order to have costs low enough to enable it to meet competition successfully. Thus, a firm considering the rural marketing of fresh concentrate should have a situation similar to Case 2 or Case 4 if it wishes to meet the price competition of regular milk. If a processing plant were of the type in Case 4, fresh concentrate could be delivered to rural consumers at a minimum cost of about ten cents per quart of concentrate below the cost of the same amount of regular milk. Under these conditions it is possible to process and deliver fresh concentrated milk at a profit.

Opinions: In an attempt to gauge consumer reaction to fresh concentrate a survey was conducted in the Central Iowa market. Of the persons living on farms, the opinions expressed (in percentage of persons surveyed) were as follows: No comment, none; good, 25.7%; very good, 35.3; excellent, 15.0; better than other milk, 3.6; good keeping quality 4.8; convenience, 2.4; can't tell difference, 1.8; can use as both cream and milk, 1.2; adverse comments, 10.2.

The sale of fresh milk concentrate has been increasing steadily since its introduction in 1951. In the near future it is planned to start another

route, with delivery every other week, to market frozen milk concentrate (kept at -20°F.).

Following the talk Dr. Iverson reconstituted samples of the concentrated milk, which were tasted by a number of those present. There was general agreement that the reconstituted milk was an excellent product.

THE CHEMISTRY OF FLAVOR CHANGES IN MILK

by

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The flavor of concentrated milks is an important consideration. Although the point needs little emphasis before this group, one should note that careful manufacture, attractive packaging, nutritional merits and convenience of use are lost causes in a milk product with unacceptable flavor. Indeed, our success with concentrated milks appears to hinge on flavor as much as on any other single factor.

Freshly processed milk ordinarily enjoys a high degree of flavor acceptability but as it is manufactured into dried, concentrated or sterilized products, and as these products undergo storage, the potent chemical effects of such agents as heat, light, oxygen, trace metals, moisture, enzymes, and microorganisms make themselves felt. As a result of the extreme complexity of milk and its sensitivity to these agents, a very large variety of off-flavors can be produced. These flavors ordinarily result from unbelievably minute degrees of chemical change and to elaborate such matters presents quite a research challenge.

Basically there are three significant aspects to any off-flavor. These are: 1. its chemical identity, 2. its specific origin, and 3. its mode of formation. Of these three, the logical point of first attack is identification of the flavor compound. Information on identity suggests logical origins which can be determined through experimentation with simplified systems. With origin and end product established, elaboration of the reaction mechanism is facilitated and frequently is self evident. The appropriateness of a proposed mechanism of course can be tested experimentally. Knowledge of the three mentioned aspects in off-flavor development can be very helpful in devising practical preventive measures.

During recent years several investigations on flavor problems in the dairy field have contributed significant advances to our knowledge. One of the most important off-flavors encountered in dairy products is that termed oxidized. In accord with its importance, no other off-flavor has received such extensive investigation, and it is hard to conceive how any other off-flavor could be so involved. At the moment the specific origin of this flavor is unknown.

A wealth of evidence has been presented to indicate that the phospholipids of milk are the source of the flavor. On the other hand, a rather

convincing case can be made for milk fat as an origin. It is known that oxygen, ascorbic acid, certain trace metals, the milk proteins, and natural antioxidants of the milk as well as lipid material are directly involved in the flavor mechanism. Current knowledge of lipid oxidation in general has relegated the flavor substances to a vague category known as secondary oxidation products. However, as far as milk lipid oxidation is concerned, light is beginning to shine on the identity of the flavor compounds. Those responsible for oxidized flavor in skim milk recently have been identified as a group of unsaturated aldehydes. The normal alkyl 2-enals containing 4 to 11 carbons inclusive, as well as several dienals, have been implicated in the flavor. Pertinent formulas are presented under equation 1*. It is notable that certain of these compounds are detectable in milk at levels of the order of parts per billion. Among the compounds identified, 2-octenal and 2-nonenal were observed to exhibit the flavor most typically.

This work by Forss and associates of Australia is in our opinion a classic accomplishment. However, it does not answer all of the questions that are posed regarding oxidized flavor. One obviously wonders how such a complete homologous series of unsaturated aldehydes is formed and whence it comes. Moreover, the Australian workers do not claim that this is a complete identification of the flavor but rather that it is one aspect which seems to be characteristic of the skim milk phase. Several other investigations, including work done at the Maryland Station, point to unsaturated aldehydes with double bonds not conjugated with the carbonyl as important contributors to oxidized flavor.

While this progress regarding the knowledge of oxidized flavor is of basic importance and promises to yield better means of controlling the defect, it must be remembered that effective antioxygenic measures such as sulfhydryl activation, addition of antioxidants (where permitted), vacuum and inert gas packing, and the avoidance of copper and iron contamination, are available to us in the processing of milk products. Despite these measures we still have flavor problems, some of which apparently are non-oxidative in nature.

In 1943, English workers observed a characteristic "butter-toffee" flavor associated with the fat phase during the storage deterioration of dry whole milk. These investigators suggested that this flavor defect might be independent of oxygen because it was not prevented by the lowest oxygen levels employed in their experiments. Since this earlier work there has been a considerable number of investigations which have revealed a flavor defect that originates in milk fat and which is not prevented by anti-oxygenic measures. For obvious reasons, the defect has been termed "coconut-like" by various workers. This off-flavor is known to develop spontaneously in the following dairy products when they are stored at room temperature: dry whole milk, dried cream, dried ice cream mix, butter-oil or anhydrous milk fat, evaporated milk, and sterilized milks and creams. From this it seems clear that the off-flavor is of basic importance. Inevitably the flavor will develop in these products and, as a consequence, there will be little difficulty in distinguishing them from their fresh

* Equations referred to are listed at the end of this paper.

fluid counterparts. Elevated temperatures are known to promote and cold storage to prevent formation of the defect.

Recently, δ-decalactone has been identified as the responsible flavor compound. The question arises as to the origin of the "coconut-like" off-flavor. As mentioned, it originates in the milk fat, and more specifically in the low-melting portion. It is known that unsaturated fatty acids with the double bond in a conducive position will rearrange to lactones. Equation 2 illustrates how 4-decenoic acid would rearrange to δ-decalactone. Milk fat contains trace quantities of the terminally unsaturated 9-decenoic acid. Synthesis of this acid and study of its tendency to rearrange to a lactone have indicated that it is not a plausible precursor of δ-decalactone in milk fat. There is, of course, the possibility that traces of other 10-carbon acids occur in milk fat and that one of these may serve as the origin of the lactone. We need to know what the specific source of this lactone is, whether the amount of the precursor varies from milk to milk and whether it would be possible to produce a milk free of the precursor. In our opinion, this research is tantamount to improving a number of the concentrated milk products, and dry whole milk in particular.

Another pertinent consideration with reference to off-flavors in milk concerns light. Recent work at the Connecticut Station has indicated that light from ordinary illuminating bulbs can have an adverse effect on the flavor of milk. It is well known that daylight, and particularly bright sunlight, produces potent off-flavors in milk. Work in our own laboratory has revealed that nonfat dry milk solids and cottage cheese when packed in glass jars develop the sunlight flavor defect. Interestingly enough, it is only a very thin layer of product next to the glass which exhibits the off-flavor. The use of large labels completely circling the container has been found effective in preventing the off-flavor.

Actually little consideration is given to the role which light may play on milk quality. Colorless glass containers are still widely employed. Glass and plastic pipes are coming into wider use in both barns and plants; surface coolers sometimes stand open with milk flowing in a thin film exposed to daylight; delivery trucks are far from lightproof; and bottled milk may stand for hours in lighted coolers and on sunlit doorsteps. Perhaps this matter deserves greater attention.

A primary cause of sunlight flavor is the compound methional, which is formed photocatalytically from the amino acid methionine in the presence of riboflavin. The essence of this reaction is presented in equation 3. Methional is indeed a disagreeable-smelling substance. It can be detected readily in milk at a level of one part in 20 million.

Another off-flavor problem on which significant progress has been made is that termed "malty." The flavor compound has been identified as isovaleraldehyde, which is produced when certain species of streptococci act on the amino acid, leucine. Milk proteins contain approximately 10 percent of this amino acid. The essence of the off-flavor mechanism is presented in equation 4. Organoleptic tests have revealed that as little as 0.5 part per million of isovaleraldehyde added to milk will closely simulate the characteristic malty flavor and aroma.

In this atomic age, interest is turning toward the application of ionizing radiations to the processing of foods. Milk has not been overlooked in this connection; and what has been encountered at the outset? Ionizing radiations produce off-flavors in milk. It has been our privilege to participate in the Q.M.F.C.I. research program on radiation sterilization of foods. We have had the opportunity to evaluate flavor of milks subjected to gamma radiations at energy levels in and above the sterilizing range. There is no doubt that off-flavors are produced under these conditions; however, the degree of off-flavor in the case of skim milk is surprisingly small in our opinion. When one considers that the engineering of equipment for treating foods with ionizing radiations has hardly begun and that energy levels short of sterilization (i.e., for pasteurization and protraction of keeping quality in fluid milk) may be of great eventual importance, it seems highly probable that ionizing radiations will have their place in the future of the dairy industry. In any event, we should make it a point to get the facts in this area, for the food industry, which uses many of our products as ingredients in processed foods, will probably find numerous applications for ionizing radiations.

One of the more important chemical changes which may occur in foods subjected to ionizing radiations involves the conversion of amino acids to aldehydes of one less carbon as shown in equation 5. This reaction also is brought about by heat in the presence of certain dicarbonyl compounds (equation 6). Sugar and sugar degradation products, which normally are present in most foods, qualify as suitable dicarbonyls. Thus in all, there are four different mechanisms, as given in equations 3 through 6, by which the 20 or so naturally occurring amino acids may be converted to flavorful aldehydes. These mechanisms involve bacteria, light, ionizing radiations, and heat; all important considerations in food processing. We feel that this basic reaction is of widespread importance in the flavor of foods.

Flavor and off-flavor identification appears to be a rapidly developing field of research. The newer techniques and instruments now available to the scientist permit microscale resolution of mixtures and identification of the resulting pure compounds. Several new tools have played a very significant role in the work which has just been discussed. The versatility of chromatography makes it as close to indispensable as any tool can be in flavor identification. It supplies at once data useful in both isolation and identification. Moreover, it fulfills the need for methods operative on a microscale. In connection with chromatography, special mention should be made of the increased value to flavor research of 2,4-dinitrophenylhydrazine derivatives, although use of the reagent is primarily confined to carbonyl compounds which are rather frequently involved in flavor. As crystalline derivatives, the 2,4-dinitrophenylhydrazones (DNPs) are particularly valuable for identification purposes because of their ease of preparation, purification, and wide range of melting points. The spectral properties, both infrared and ultraviolet, and chromatographic behavior with both column and paper techniques have rendered these hydrazones even more useful. As a case in point, data we have obtained, as well as those by others, reveal the ease with which various lower molecular weight carbonyl compounds can be separated as DNPs on paper. Cutting the spots from such chromatograms and heating them with levulinic or other suitable carbonyl acids frequently will regenerate the

parent compounds sufficiently to enable their presumptive identification by odor. Recent work at the Maryland Station has shown that DNPs, in most instances, can be quantitatively decomposed to the parent carbonyl by heating with an excess of levulinic acid.

It seems appropriate here to mention our enthusiasm for infrared spectral data as an aid in identification work. The complete coincidence or superimposability of infrared spectra for a known and an unknown compounds in the 2-to-15-micron region is generally considered excellent evidence that the two compounds are identical. The advantage of this application to flavor research lies in the fact that as little as one mg. of pure compound will ordinarily yield a satisfactory spectrum, that the spectrum furnishes evidence regarding functional groups, and that the compound is available for further tests and observations following spectral analysis. Within the past year or so infrared spectral data have figured prominently in the solution of two flavor identification problems in our laboratory.

It has been mentioned that information on off-flavor origin, mechanism of formation, and identity can be helpful in practical prevention. Let us consider for the moment a hypothetical case. One can expect that milks with relatively high free amino acid content will make products which are susceptible to off-flavors produced by heat, light, and storage. For example, as little as 4 p.p.m. of added methionine will greatly increase the susceptibility of milk to sunlight flavor. The question then may be raised, "How does one obtain milk of low free amino acid content?" The logical answer is through careful selection and proper handling of the milk. On this basis, we would certainly reject milk of poor bacterial quality; following milking, we would cool and pasteurize as quickly and efficiently as possible in order to minimize proteolytic enzyme activity; and we would avoid using proteolytic enzyme type antioxidants in milks for concentrated products manufacture.

But what about the normal free amino acid content of milk? Does it vary with the season, the breed, feed, etc.? Specifically what free amino acids are present, do they vary in numbers as well as levels? Answers to these questions may be very important. Although it is known that milk contains only traces of free amino acids, the amounts present could easily be of importance from a flavor standpoint. If for example Holstein milk from the Wisconsin area during the spring flush were lowest of all milks in free amino acid content, such milk might be ideal for manufacture into certain concentrated products. The point of all this is that we can't begin to develop an ideal milk from the standpoint of resistance to an off-flavor if we know nothing about the fundamental nature of the flavor. Most of our concentrated products are tailor made for particular uses. When we know exactly what is to be avoided regarding off-flavors, perhaps a tailor-made raw material for our products can be sought. It is even conceivable that some day cows will be selectively bred toward this objective.

Reflection on the nature of flavor and other problems presented by concentrated milks reveals the need for more adequate knowledge of milk itself. The era is past when information on the gross composition and more obvious properties of milk were adequate to contend with our problems. The significance of trace substances and minute chemical changes in milk are readily evident in the field of flavor research. If we are to keep pace with the

aggressive progress in the rest of the food industry, we cannot remain content with the natural merits of milk, that it is palatable and nutritious. We should bring to bear the full brunt of modern scientific knowledge and techniques on problems with milk so that it will be the optimum product in any form. In the vernacular of the day, milk is a many splendored thing but let's not rest on the splendor.

Mechanisms of certain off-flavors.

1. Oxidized flavor in skim milk.

$$\text{Phospholipids?} \xrightarrow{[O]} R-CH=CH-CHO$$

Alkyl 2-enals ($C_4 - C_{11}$)

$$CH_3-(CH_2)_4-CH=CH-CHO$$

2-octenal

$$CH_3-(CH_2)_5-CH=CH-CHO$$

2-nonenal

2. Coconut-like flavor of certain stored products containing milk fat.

$$CH_3-(CH_2)_4-CH{=}CH-(CH_2)_2-COOH \xrightarrow{\Delta} CH_3-(CH_2)_4-CH-(CH_2)_3-CO + H_2O$$

4-decenoic acid $\qquad$ δ-decalactone

3. Sunlight flavor in milk.

$$CH_3-S-(CH_2)_2-CHNH_2-COOH \xrightarrow[\text{riboflavin}]{[O]} CH_3-S-(CH_2)_2-CHO + NH_3 + CO_2$$

methionine $\qquad$ methional

4. Malty flavor in milk (microbiological).

$$(CH_3)_2-CH-CH_2-CHNH_2-COOH \xrightarrow{[O]} (CH_3)_2-CH-CH_2-CHO + NH_3 + CO_2$$

leucine $\qquad$ isovaleraldehyde

5. An action of ionizing radiations on amino acids.

$$CH_3-CHNH_2-COOH + OH \longrightarrow CH_3-CHO + NH_3 + CO_2$$

alanine $\qquad$ acetaldehyde

6. Action of heat on amino acids in presence of 1,2-dicarbonyls (The Strecker degradation)

$(CH_3)_2 - CH - CH_2 - CHNH_2 - COOH + CH_3 - CO - COOH$

leucine $\downarrow$ pyruvic acid

$(CH_3)_2 - CH - CH_2 - CHO + CH_3 - CHNH_2 - COOH + CO_2$

isovaleraldehyde alanine

METHODS AND PROBLEMS IN THE PRODUCTION OF SPRAY-DRIED MILK

by
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In discussing methods and problems in the production of spray-dried milk I shall mention methods only to the extent to which I consider them appropriate in developing the problems. Actually the problems resolve themselves to a very simple proposition. We would like to be able to produce spray-dried milk which on reconstitution would be identical with the fresh fluid milk from which it was produced and have the physical characteristics of dissolving instantly and completely. Dr. Herreid was optimistic. I would like to add my optimism with respect to this particular problem.

We normally conceive of spray drying as consisting of three operations: atomization, evaporation from drops, and the flow and mixing of gases and particles. Atomization is not a particularly pertinent factor insofar as the ultimate quality is concerned. Normally we atomize either with pressure spray or with a centrifugal atomizer. We can get approximately equivalent results from both. Or we could atomize with a two-fluid atomizer, although these have not been widely used in this industry. There has been considerable interest in a two-fluid atomizer using the drying air as the atomizing medium. I personally have a great deal of interest in that method of atomizing, and believe it offers an inherent advantage in the very rapid and complete mixing of the spray and the air stream. We have been very successful on a pilot-plant scale in getting one of these atomizers to work. We have not been so successful with commercial operation.

Commonly those interested in drying like to develop mathematical relationships. Drying under static conditions such as in tray drying is relatively easy. In spray drying, where you are dealing with very small particle size and very rapid rate of drying together with rather rapid changes in the drying conditions, mathematical relationships are rather difficult to evolve. In tray drying they speak of two stages of drying; the constant rate period and the falling rate period. We have not been able to recognize any clearly defined constant rate period in spray drying. From experimental data we have obtained, we found that there was a rather constant drop in the drying rate until a moisture level of about 20% was reached, after

which there was a rather rapid drop in the drying rate. With pure liquid drops you would be dealing only with the constant rate period. Duffie and Marshall, of the University of Wisconsin, have shown that the time of drying for pure liquid drops increases as the square of the diameter of the particle. Particles up to 20 or 30 microns in diameter will dry in a fraction of a second. Larger size particles may take several seconds. With milk products there is no clearly defined constant rate period, and during the falling rate period the relationship becomes rather confused. Certainly the rate of drying during the constant rate period increases at least as the square of the diameter of the particle. The rate of drying during the later stages of drying is dependent upon the movement of water to the surface, and as the concentration increases, this becomes rather slow. Now, in tray drying, the drop in the rate of drying during the falling rate period is due to the movement of the zone of drying from the outside of the particle to the interior. We can demonstrate no such proposition in the spray drying of milk. If there is a movement of the zone of drying from the surface to the interior of the particle, you would expect distortion at the surface of the particle and microscopic examination does not reveal any such distortion.

If the rate of drying is dependent upon movement of water to the surface of the particle, you would expect large particles to have a higher moisture content in any given stage of the drying operation or at any given time interval than smaller particles, and we find that to be true. We took two samples, each of which had an initial moisture content, that is a composite moisture content, of 3%. We sieved the material and got particles ranging from those retained on 80-mesh screen up to those that passed through 180-mesh screen and found that the small particles had a lower moisture content than the bulk and the large particles had a higher moisture content than the bulk. We have always been rather surprised as to how slowly that equilibration takes place. Obviously they will eventually equilibrate. But after 24 hours, the smaller particles still had a lower moisture content than the bulk and the large particles a higher moisture content. In another sample the equilibration had not taken place even after 72 hours.

The driving force for the drying operation can be expressed as (p_w-p_a) where p_w and p_a are the vapor pressures of water associated with the particles and with the air, respectively. As the powder leaves the air stream p_w should approach p_a. But only the surface of the particles will be in equilibrium with the drying air. That is just another way of expressing the same relationship that is shown by the difference of the moisture content of the large and small particles.

The difference in the moisture content of large and small particles has not been of too great significance in this industry prior to the development of the instant powders. With the instant powders, however, and the emphasis on larger size particles, this has become of rather considerable significance in determining the conditions required to reduce the moisture content of the powder to the required level.

Obviously, if the outside of the powder particle, vapor pressurewise, is in equilibrium with the air, then the humidity of the exit air must influence the moisture content of the powder. There is a general relationship between the exit air humidity and the moisture content of the

powder. I might say that the normal exit humidity from the drier would be in the neighborhood of .04 to .06 pound of water per pound of dry air. Obviously, since the exit air humidity is the sum of the inlet air humidity and the moisture pickup during drying, there should be a similar relationship between the humidity of the inlet air, and the moisture of the powder. There has been a great deal of confusion in the industry with respect to the relationship between the exit air humidity and the moisture content of the powder. Admittedly, this is difficult to show under commercial operation for two reasons. First, anything that changes the particle size would upset this relationship. Second, the use of a redrier would upset the relationship. So very commonly in commercial operations the statement is made that there is very little, if any, relationship between the exit air humidity and the moisture content of the powder. In dryer operations we do not control the humidity of the inlet air. It can be done, but it is expensive. But certainly the humidity of the inlet air, and consequently the humidity of the outlet air, does vary rather widely, either by changes in moisture content of the air itself or because of leaky coils.

The temperature of a droplet of water during drying would be by definition that of the wet bulb temperature of the air. With a droplet of the milk the situation is somewhat different. Materials in solution or suspension lower the vapor pressure. Contrary to expectations, Marshall and associates at the University of Wisconsin have shown that the droplet evaporates with a surface temperature corresponding to that of the saturated solution even though the concentration is less than saturated. However, even taking into consideration the lowering of the vapor pressure due to materials in solution and suspension, the temperature of the particle (as long as the surface is fully wetted with water) will never exceed about 140° F., depending, of course, on the humidity of the air. The temperature of the particle, after the surface is no longer completely wetted with water, will vary depending upon the design of the dryer and on the operating conditions.

Dryers can normally be classified with respect to air-powder flow as either cocurrent or countercurrent. Actually, no dryers are in use or have been developed which provide strictly countercurrent air-milk flow. Considerable numbers are in use that provide at least partially countercurrent air-milk flow. With strictly parallel air-milk flow, the temperature of the particle will never exceed that of the exit air temperature from the dryer, which may be in the order of 170° to 180° or possibly 190° F. If, however, you have partially countercurrent air-milk flow, the temperature of the particles may approach rather closely that of the inlet air, which may be as high as 300-400° F. This is a very pertinent factor in determining the extent of heat damage. Also, I should like to mention in this connection the possibility, which is ever present in most dryer designs, of recycling of partially dried material back into the hot air stream.

Dryers may be also classified as either updraft, downdraft or horizontal with respect to air flow, or as straight-line or rotary flow. Rotary flow has frequently been used with the idea of increasing the flight time of the particles in the air stream. Virtually every combination of these three general relationships has been used in dryer design. Since all of them are used, it should be obvious that probably no one design offers

maximum advantages in all respects. Unfortunately, dryer design is still largely on an empirical or cut-and-try basis. It would be extremely difficult to evaluate all variables which are possible.

We normally evaluate heat damage in terms of solubility index, which is a measure of the amount of casein destabilization which has occurred, and in terms of burnt specks. The time to precipitate a given amount of casein on heating increases almost semilogarithmically with increase in concentration up to about 88-90% solids. Above that concentration, the milk protein becomes rather heat stable. In drying you must pass through the moisture range of maximum instability, which is around 90% solids.

In cocurrent flow dryers, there is a general relationship between the exit air temperature and the solubility index. As you get above a critical exit air temperature the solubility index increases about semilogarithmically with the temperature of exit air. This critical air temperature will vary primarily with particle size because the smaller the particle size the faster the drying and consequently the shorter the period of time in going through the critical range of concentration. Also, it will vary with dryer design. If you're dealing with countercurrent air-milk flow, it will also vary with the inlet air temperature, since the particle comes into contact with the inlet air as it approaches dryness.

I'm not going to dwell on burnt specks except to indicate that they are a general problem. They result usually from recycling of dried particles back into the hot air stream, or they may develop wherever milk powder becomes lodged for a protracted period of time.

In spray dryer operation, we normally control the inlet air temperature. For reasons of economy we want to use the maximum inlet air temperature possible; actually dryers are in use using inlet air temperatures up to 500°F. and above. Theoretically, there is a maximum since the cooling effect on the air is due to evaporation of water. Under any given set of conditions, the higher the inlet air temperature, the greater the moisture content of the powder because the higher the humidity of the exit air. We vary the outlet air temperature within the limits imposed by moisture content and heat damage. We always run into the fact that there is a conflict between moisture content and heat damage. The larger the particle size, the slower the drying time and, in general, the higher the moisture content. So you can get into a situation where you cannot raise the outlet air temperature without excessive heat damage. The only recourse then is to reduce the particle size. There is a general relationship between the viscosity of the condensed milk and the particle size. Viscosity can be varied either by changing the temperature of the concentrate or by changing the concentration. Frequently during hot, humid days, we must have recourse to reducing concentration in order to reduce the moisture content without increasing heat damage.

I have been a little uncertain in this talk as to just what to say about instant powder. I am sure you understand my position in the matter. There are gentlemen in the room representing various companies who surely know a great deal more about the processes they are using than I. I will, however, make some general statements with respect to instant powder because of its importance. The methods in general are two. First, aggregation of

particles already formed, and, second, spraying so as to secure large particles. I am sure that anyone here could conceive of a variety of ways of effecting aggregation. One method which has been published consists essentially in wetting the powder to a slurry, followed by redrying. This, incidentally, permits lactose crystallization. Another method, which I understand is commercially used, is the introduction of moisture vapor into a stream of pneumatically conveyed powder, thus effecting aggregation of the particles. Still another is recycling of the fines back into the normal spray in the drying chamber. Then means can be used to permit aggregation shortly after spraying within the normal drying operations. This is effected by atomizing into a very high velocity stream of air at a high temperature, using high concentration, so that the surface of the powder becomes sufficiently tacky for particle aggregation to occur.

There is a tremendous amount of interest in instant whole milk, and I, for one, am quite optimistic that eventually someone is going to effect the break-through the same as was done with nonfat powder. The problems, however, are rather considerable. Basically, the situation is as follows: As long as the fat is in the liquid state there is no problem of wetting. Wetting can be secured of course by warming the powder, by warming the water, or by using a fat which has a melting point lower than butter oil. For instance, you can make a beautiful instant powder using corn oil. With butter oil, however, which is the product we are interested in, the fat crystallizes at normal storage temperature, and it is the crystalline fat which retards and prevents wetting and subsequent dispersion of the particles. I am sure that each of you could think of a considerable number of ways to keep the fat in place, and I assure you that in my own personal experience a great many of them have been tried. But, obviously, so far we have not been successful in getting the fat to "stay put." It remains for a while but not over the protracted period of storage necessary to secure a satisfactory product. I am, however, quite confident that, with sufficient incentive, someone will break the barriers and make a fat product which is as instantly dispersible as our present instant nonfat product. Having an instant fat product, I have every confidence that most of the other problems, at least in respect to dried whole milk, can be solved.

Discussion

R. K. Eskew: I would like to get some idea of the time and the storage conditions that might be expected to result in this loss of dispersibility because of the fat.

S. T. Coulter: As soon as there has been sufficient time at a temperature at which the fat will crystallize, which may be a matter of 24 hours, there is a noticeable loss in dispersibility. This becomes progressively worse over continued storage. You can use a variety of emulsifying agents, and Dr. Hollender will talk this afternoon about the use of emulsifying agents of various kinds. They have an effect and a very helpful effect. And I rather suspect that if you could hold materials of that kind at a constant temperature you might get the fat to "stay put," but with fluctuating temperature, and resultant melting and thawing

of the fat, the fat migrates; at least I have no other explanation for what happens. So those powders lose dispersibility on storage. They may be satisfactory over a period of a month or more, but it has been our experience that they ultimately lose their dispersibility.

Comment: The difference in moisture content of the small particles and large particles and their failure to equilibrate on storage suggests that there could have been a compositional difference, maybe, in lactose content or something.

S. T. Coulter: They will equilibrate on storage, but they equilibrate very slowly. Now we got into this in freeze-drying comparatively large chunks of milk. We found that freeze-dried particles rather large in size took months to equilibrate.

S. R. Hoover: I don't want to anticipate Dr. Hollender's talk, but does there appear to be any effect of the fat level in the milk products when dried? In other words, if you were drying a product of 2-1/2 to 3% fat versus one of 4 or 5%?

S. T. Coulter: We have not investigated the fat level question thoroughly. Certainly as the fat is reduced you reach a point at which fat would no longer be a factor, but that is far below the normal fat level.

S. R. Hoover: I wonder if any of the industrial people would like to talk about this instant milk.

P. A. Wells: Would anybody like to make any comments?

No comments.

DISPERSIBILITY OF DRY MILKS

by

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Introduction

During the past four or five years, considerable effort has been put forth on methods for improving the dispersibility of dry milks.

Although the emphasis of the QM Food and Container Institute was mostly in terms of dry whole milk, industry apparently was doing a lot of research on nonfat dry milk. This is evident by the fact that the first instant powder was introduced some 18 months ago, and now there are at least 12 commercial products available.

To date, we have not seen an instant dry whole milk although it is still hoped that with the knowledge industry has gained in the development of the nonfat products that such a product containing fat will be possible.

Dry Whole Milk

The QM Food and Container Institute supported a considerable amount of research on methods for improving the dispersibility of dry whole milk. Although an instant dry whole milk was not developed, certain information was accumulated which may help in the eventual development of such a product.

The information available may be divided as follows:

1. Influence of certain processing procedures.
2. Influence of wetting and/or surface active agents.
3. Influence of particle size.
4. Influence of water and powder temperature.
5. Influence of free fat.

Ashworth[1] and his group at Washington State College, in studying variations in standard processing procedures that might influence the dispersing characteristics of dry whole milk found that: (1) a fat level of 5-10% in the powder was beneficial; (2) homogenization efficiency was of considerable importance, especially if the fat level was above 10%; (3) drying air temperature had little effect if the moisture content of the powder was in a range of 2-4%; (4) the optimum total solids level of the condensed milk was 40-48%; and (5) other variations did not produce significant changes.

In general, most manufacturers would likely consider these conditions desirable for a good quality powder. Although by the wide variations seen in the dispersing characteristics of powders from the same manufacturer, it would appear that processing controls are not as good as they should be. Variations, if any, caused by variations in the raw milk supply have not been studied.

It is very probable that the fat level will be of considerable importance, especially in the development of an instant product.

Hibbs and Ashworth[2] were the first to report the influence of certain emulsifiers and/or wetting agents on the dispersing properties of dry whole milk. They were able to show definite improvements in the wetting properties of the dried milk to which certain emulsifiers were added before drying. However, churning was encountered with certain of the most effective additives when the powder was reconstituted.

Mather and Hollender[3] made a rather extensive study of the influence of wetting agents on the properties of dry whole milk. They also were able to show that these wetting properties could be increased by the addition of certain surface-active compounds. This was found to be true when the dispersing properties were measured by both the rate of dispersion and self-dispersion methods of Stone et al.[5]

As mentioned previously, Hibbs and Ashworth found that when the surfactants were present in the powder, the butterfat had a tendency to churn during

reconstitution. Mather and Hollender were generally able to control the churning by using a combination of hydrophilic-lipophilic surfactant, such as 0.5% Tween 60 plus 0.5% Span 60. By using such combinations, it was generally possible to control the churning defect without reducing the effect of the surfactant to any degree.

In order to determine the commercial feasibility of the use of surfactants in dry whole milk, the Food and Container Institute made a limited procurement of the product with and without surfactants. Three lots of approximately 400 pounds each were procured. They were (1) control, (2) 0.5% Span 60 plus 0.5% Tween 60, (3) 0.08% Peg 42 plus 0.02% distearate. To each of the lots containing surfactants was also added 0.06% Na citrate. The powder was gas-packed in the regular manner and shipped to the Institute for storage studies. Dry whole milk which was manufactured at about the same time on an Army contract was also used for comparison in the study.

After storage for one year at 40, 72 and 100° F., with withdrawals at regular intervals, it was found that the surfactants were effective in improving the self-dispersion and rate of dispersion. In general, storage time and temperature had little effect on Peg 42, but storage at 72° F. and 100° F. significantly decreased the effectiveness of the Span-Tween combination.

Although the study did show that beneficial dispersing characteristics could be obtained by the use of surfactants, the improvements did not eliminate the typical "balling up" that occurs when powders are mixed with water. A serious stability problem was encountered when the powder was held at 100° F. There was a rapid decline in flavor acceptance, with soapy flavors becoming evident, thus eliminating the practical use of these compounds.

During the past months, the influence of particle size on the dispersing characteristics of nonfat solids has become of considerable importance. Swanson and co-workers(6) have shown that an intermediate range (30-50 mu) is the most desirable. In their experiments, particles which were coarser than this sank in the water rapidly, but did not disperse or dissolve well. They were not certain as to what the cause for this was.

Because of particle-size fractionation difficulties with dry whole milk, they were not able to determine the dispersing properties of different sizes of dry whole milk as such. The "free fat" had to be removed before fractionation could be carried out. After the removal of the free fat, the intermediate size was found to be the most desirable.

The influence of crystalline lactose on the dispersing properties of dry milks has been a subject of considerable speculation especially since the first instant nonfat product contained a considerable amount (50% or more) of the lactose in the crystalline form.

There is a lack of information on the rate of lactose and especially crystalline lactose on dispersibility.

Hollender and Lundegard(7) studied the moisture adsorption of dry whole milk in thin layers at various temperature and relative humidities in relation to the lactose crystallized. They found that approximately 9% moisture was needed before 50% of the lactose could be expected to crystallize.

The time to reach this moisture level was, of course, related to the temperature, the relative humidity, and how the powder was exposed.

At the moisture level of 7-9%, the powder becomes very sticky and agglomeration of the small particles readily takes place. Heat damage to the proteins at temperatures of rapid moisture adsorption will be severe unless exposure time is very short.

The relationships between crystalline lactose, particle size, and dispersibility have not been reported.

By allowing for moisture pick-up and the resulting increase in particle size, Hollender and Lundegard were able to prepare very small quantities of dry whole milk with an increased amount of crystalline lactose, but the dispersing qualities were not necessarily improved. However, the amount of free fat was increased considerably and it appeared that this surface fat prevented wetting and subsequent dispersion.

Swanson(6) found that if the "free fat" was removed from regular dry whole milk, the dispersing properties were greatly improved.

Stone et al (4) found that warming dry whole milk before reconstituting markedly improved its dispersing properties. By heating the powder to 140° F. they were able to show approximately a threefold increase in the 10-second rate of dispersion in cool water.

Thus it appears that the development of an instant dry whole milk may hinge on controlling the free fat and its characteristics as well as increasing the particle size.

NONFAT DRY MILK

During the past year, we have accumulated considerable information on the dispersing properties of the instant nonfat products as well as on their keeping qualities.

A survey is currently being made of the various products on the market in an attempt to arrive at a range of dispersibility that can be used to describe or define an instant product.

A study of samples of instant nonfat dry powders sent in by various manufacturers showed that there was a considerable variation in dispersibility among so-called "instant" products, whether measured by the self-dispersion method or the rate-of-dispersion method. However, when measured by rate of dispersion, the greatest differences are registered in the first 10 seconds and by the end of the 40-second stirring period, the differences in most cases have become less.

Where the dividing line should be, in order to define a truly instant product, has not been determined.

Earlier studies on a smaller group of instant type powders indicate that there is not an appreciable change in the dispersing properties of these products when stored so as to prevent moisture pick-up.

For comparison purposes, the results by these same methods for several "high" and "low" heat samples have been determined. It was found that three of the low heat samples have fairly good self-dispersion values, but the 10-second rate of dispersion is relatively poor.

Conclusions

1. Fat contents of above 10% are detrimental to the wetting properties of the powder.
2. Homogenization efficiency is important if the fat content is 10% or above.
3. The addition of certain surfactants to the milk before drying will improve the dispersing characteristics of the resulting dry whole milk.
4. Off-flavors may develop in dry whole milk containing surfactants when stored at 100° F.
5. An intermediate particle size (30-50 mu) improves dispersing properties.

6. Free fat and the state or "condition" of this surface fat are important to good wetting properties.

7. There are wide variations in the dispersing properties of commercial instant nonfat dry milks.

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DISCUSSION

Question: How many grams of powder do they drop into this in order to determine the figures here?

Answer: (Dr. Hollender, QMC) The rate of dispersion is determined with 52 grams and 400 ml. of water, water at 75°, and the self-dispersion is 15 grams and 90 ml. of water--that's in a Buchner funnel. The rate of dispersion is determined with a mixer with a bowl with a hole in the bottom so that the material can be drawn out at a 10 sec. or 20 sec. or 30 sec. interval. This was presented by Stone, et al. at the Dairy of Science meeting, I think 2 years ago.

Question: Did you find, Sir, that some of the milk powders that had a very high density had better dispersion than the light powders, some of which probably have the best dispersion.

Answer: (Dr. Hollender, QMC) You mean on this rate of dispersion, where we use mechanical agitation? I don't think so. We don't have any density measurements. We are working on that at the present time. The product which is probably the least dense of all the products has both the highest rate of self-dispersion and the rate of dispersion.

Dr. Patton, Penn State University: I don't think we have resolved this point at all, about whether the crystallization of the lactose is a more important or less important factor than the density of the particle. It seems to me that we've got representatives of companies here who could be able to tell us something about this.

Dr. Wells: I would go along with that. This would be an operation of taking down our hair. Does anyone care to comment on that point?

Dr. Hartman, White House Company: It depends on what you're talking about on density, whether you're talking about the density of the original powder or the instant.

Dr. Patton: (Penn State U.) I'm a greenhorn at this but what I'm trying to get at is that in the manufacture of instant milk is it more important, in getting a better product, that we get the lactose crystallized either wholly or partially or do we have a better chance of success by control of particle size?

Dr. Hartman: I think that the answer is quite obvious if you go back and take a good look at regular powder. If you take regular nonfat dry milk solids and add a sufficient quantity of water, it will immediately and completely disperse. For example, I've seen that demonstrated by taking a handful and throwing it a wash sink full of water, a large type wash sink, and before you can even think, that powder is completely gone, dispersed, completely dissolved, or soluble. And I think therein is your answer,

that if you can make the powder wet, you will solve your dispersion problems. In other words, the original powder, or plain nonfat dry milk solid is dispersible. It's a question of wetting it; or spreading the particles so that they can be wetted, let's put it that way. I really don't think that lactose has any bearing on the problem.

Dr. Wells: Well there, now we've got an answer. Does someone disagree with that?

Dr. Coulter, U. of Minn.: I might make this comment. I think it should have been obvious from what I said this morning that if the powder, the so-called instant powder, is made both with and without lactose crystallization, as Dr. Hartman has said, it's a question of preventing the "balling up" that occurs when the normal powder is wetted with water. Get the physical characteristics of the powder so that you do not get the "balling up."

Dr. Wells: You agree with Dr. Hartman. He says that the lactose has nothing to do with it.

USE OF ELECTROLYTIC TIN PLATE IN PACKAGING OF MILK CONCENTRATES

by

E. A. Tjarks, New York, N. Y.

1- Production

The seizure of the world's most productive source of tin ore by Japan during World War II, combined with small amounts of stock available, accelerated the movement toward large scale production of electrolytic tin plate, until at the present time approximately 70% of all tin plate produced is electrolytic, and the percentage is increasing every year. Production in tons since 1942 shows the following pattern:

	ELECTROLYTIC	HOT DIP
1942	82,000	2,578,000
1945	862,000	2,046,000
1950	2,841,000	1,911,000
1954	3,680,000	1,307,000

2- Some Properties of Tin Plate

Tin plate is essentially a thin mild steel sheet coated with a much thinner layer of tin. If we could visualize it as a nine-layer sandwich, it would be constituted of a steel base filling, on each side of which is, successively, an alloy layer, a tin layer, a protective oxide layer, and an oil layer. The ability to resist corrosion is dependent on the nature of one or more of these layers.

Hot-Dipped Tin-Plate Manufacture - Cold or hot rolled sheets approximately 20 by 30 inches are pickled, fluxed, passed through a pot of molten tin,

cooled, cleaned, oiled, and assorted.

Electrolytic Tin-Plate Manufacture - Temper-rolled coils, approximately 36 in. wide by 15,000 lb. or larger are electrolytically cleaned, pickled, electrolytically tinned, flow brightened, chemically dipped, rinsed, oiled, and sheared or again coiled.

Differential Electrolytic Tin Plate - One weight of coating is applied to one side of the sheet and another weight to the other side. To differentiate between the different coating weights, one of the sides is given a distinguishing mark or finish.

The chemical specification for base steel for the manufacture of hot-dip and electrolytic plate is as follows:

Element	% Permitted		
	Type L	Type MR	Type MC
Phosphorous	.015 max.	.020 max.	.07 - .11
Copper	.06 max.	.20 max.	.20 max.
Carbon	.05 - .12	.05 - .12	.05 - .12
Manganese	.25 - .60	.25 - .60	.25 - .60
Sulphur	.05 max.	.05 max.	.05 max.
Silicon	.010 max.	.010 max.	.010 max.
Nickel	.04 max.	NO LIMITATION SPECIFIED	
Chromium	.06 max.	" " "	
Molybdenum	.05 max.	" " "	
Arsenic	.02 max.	" " "	

It will be noted that the principal variations in the impurities tolerated for the different types are in the phosphorous and copper content and in the maximum tolerance in Type L steels for the tramp elements, nickel, chromium, molybdenum and arsenic.

The type steel used mostly for electrolytic tin plate intended for the milk industry is Type MR; a small amount of Type L is also used. Type MC, because of its high phosphorous content with probable decrease in corrosion-resistant qualities is not used.

Characteristics of Tin Plate

The Unit of Area is the base box originally defined as 112 sheets each 20 by 14 in. or the equivalent of 31,360 square inches of tin plate. Since both faces of tin plate are tinned, the area of tinned surface is 62,720 square inches of tin plate.

THICKNESS OF TIN COATING

Weight per Base Box	Thickness of tin coating each face
.25 lb.	.0000152 in.
.50 lb.	.0000303 in.
.75 lb.	.0000455 in.
1.00 lb.	.0000606 in.
1.25 lb.	.0000758 in.

The overall thickness of tin plate commonly used for evaporated and condensed milk is:

80 lb. tin plate - .00878 in.

The coating weight used at present for evaporated and condensed milk is 1.25 lb. per base box for hot dip and .75 lb. per base box for electrolytic tin plate.

The electrolytic deposition of tin results in coating the steel base with tin more uniformly, the average tolerance in the .75-lb. range being $\pm$ .05 lb. per base box; for hot dip in the 1.25-lb. range $\pm$ .15 lb. per base box.

3- Problems in the Use of Electrolytic Tin Plate

With the continued commercial use of electrolytic tin plate came the realization that it had characteristics entirely different from hot-dip tin plate, and that many problems would arise that would have to be overcome before a satisfactory plate would be made available. Such problems, in addition to corrosion resistance, included the consideration of characteristics governing satisfactory can fabrication. Some of the factors encountered have been:

a- Abrasion of tin plate during transit, occurring also in hot-dip tin plate, and resulting from a shifting of the plate, causing minute black spotting.

b- Rancidity of oil film on continued storage of the tin plate.

c- Drying out or oxidation of oil film on plate through continued storage.

d- Discoloration or sulphide staining of plate after continued storage under unsatisfactory conditions.

e- Growth of oxide film with continued storage

f- "Burn-on" of evaporated milk

4- Types of Corrosion

a- Evaporated Milk Cans

Five types of corrosion have been observed inside evaporated milk cans:

a- Fire burn or discoloration (gray to deep black) along the body edges of

the can resulting from the sensitivity of the tin plate to heat in can fabrication.

b- Corrosion along the body seam inside the can, gray to blackish in color, also a can fabrication problem.

c- Corrosion of the entire body area of the can, grayish to blackish, due to inherently poor quality of the tin plate.

d- A grayish to blackish pitting corrosion of the can ends only.

e- Scored lines across the body of the cans, gray to black in color. These are occasionally found on some tin plate which is dry (insufficient oil) or of poor quality and results from a scratching during can fabrication.

Usually the exterior edge of cans showing a pronounced fire burn will be found bluish to blackish in color.

b- Condensed Milk Cans

In the past few years, corrosion has been noticeable in some lots of condensed milk cans on and off the embossing and profile of the ends, particularly the end stored up and at the junction of the body seam and end seam. The corrosion starts as a light brownish spot and rapidly becomes larger and darkish green in color.

5- The Cause of Corrosion

At present the majority of investigators lean to the theory that corrosion on the inside surface of evaporated milk cans is due to breaks in the oxide film on the surface of the tin plate with the resultant setting up of localized differences of electrical potential. The reaction is initiated during the sterilizing period and is progressive to the point of being noticeable as a grey to black deposit or discoloration. Investigators have concluded it is probably the sulphides and oxides of iron or tin or a mixture of both.

The corrosion spots of condensed milk result from the effects of air (oxygen) and condensed milk on tin plate which has some inherent defect in its composition characteristics which renders it particularly sensitive to an aerobic corrosion.

6- Appearance of Desirable Electrolytic Tin Plate

Desirable electrolytic plate made up into evaporated milk cans shows a slight pattern of crystalline etching soon after sterilization. On continued storage this pattern becomes more pronounced, slightly darker in color, and is apparent over the entire plate. No corrosion of any type will be found along the body edges or seams. The crystal etching pattern is very small in contrast to hot-dip plate and does not have the spangled appearance of such plate.

7- Results of Some Investigations of Electrolytic Tin Plate

In the last few years many experiments have been conducted at our laboratory

in conjunction with our tin shops and in collaboration with the various tin-plate producers. One of the first studies revealed the considerable differences that existed in tin plate from different producers and even in different lots of plate from the same producer. Later studies have shown the necessity of the tin-plate industry to produce a tin plate tailored particularly for evaporated or condensed milk. General-purpose plate manufactured by them is usually unsatisfactory. One investigation showed a lessening but not an inhibition of corrosion when evaporated milk was packed in an atmosphere of nitrogen. All studies made so far have shown that a satisfactory electrolytic plate made into cans has a longer shelf life than the milk product it contains.

At the present time experimental studies are being set up to evaluate suggested chemical and physical tests which might help predetermine the corrosion resistance of electrolytic plate in as short a time as possible. Most of these tests involve an accelerated corrosion of the plate using some acid or salt solutions with either visual grading or electrical measurement.

8- Routine Quality Control Testing

All shipments of tin plate, whether hot dip or electrolytic, are sampled immediately when received at the tin shops and representative sheets taken for coating weight determination and corrosion resistance testing. The coating-weight figures indicate the trend as to this characteristic. Low results are immediately rechecked and all such results drawn to the attention of the tin-plate producer. For the corrosion resistance test, an entire unit of a shipment is made up into cans and twelve are taken to reflect a normal can fabrication for that particular producer's plate. The twelve cans are forwarded to the nearest milk plant for processing with the regular production of evaporated or condensed milk. The completed samples are then sent to our New York Control Laboratory and stored at 95° F, six cans being examined after 30 days and six cans after 60 days. When opened, a physical examination is made of each can for the appearance of and type of corrosion, if present, and also of the milk. Periodically samples and findings are shown to and discussed with the tin-plate producer. Special samples involving specific problems of production are examined as required.

9- Sources of Tin Plate

Before any producer is placed on the Borden Approved List as a desirable source of electrolytic plate, extensive tests are made of representative tin plate for can fabrication and corrosion resistance qualities. Present sources of tin plate reflect such studies. Although not all shipments and producers are 100% perfect, the constant control tests outlined above and those made at the tin shop for fabrication qualities tend to keep undesirable tin plate to a minimum.

DISCUSSION

Question: It appeared from the panels that were passed around that the etching pattern can be changed by retreatment.

Tjarks: Mr. Vaurio, of U. S. Steel Research Laboratory, is best qualified to answer the question of the methods of retreatment.

Vaurio: The picture, as far as the pattern of corrosion, is determined almost 100% by the type of oxide film that is laid on the plate right after the melting operation. The type of oxide film is determined by how the filming treatment is applied. The usual filming treatments are oxidizing solutions such as chromic acid or chromates and phosphates, either with or without electric current. In the electrochemical treatment we have a two-phase treatment. In the first pass which is the cathode, the tin plate is cleaned, and in the second pass, which is the anode, the protective film is laid down on the surface of the tin. That's the usual method which Mr. Tjarks referred to as the general-purpose tin plate. We recognize that for evaporated milk we have to have a tailor-made product, one whose protective film is much more effective than the film used for the general-purpose tin plate. In the electrochemical method the anodic portion of the film treatment is eliminated.

Hartman: What is the effect of complete removal of oil base on "burn-on"?

Tjarks: We haven't tried it, but you cannot make a can without an oiled surface. In the first place, you scratch the tin plate in fabrication and "fire burn" it so you would have a badly corroded plate after processing.

Wells: You mentioned cottonseed oil was used; I thought that palm oil was used for tin plate.

Tjarks: Palm oil is used in the hot-dip process, but cottonseed oil is used for electrolytic.

LIST OF ATTENDANCE

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Abbott, G. S.	Abbotts Dairies, Inc.	Philadelphia, Pa.
Aceto, N. C.	Eastern Utilization Research Branch	Philadelphia, Pa.
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